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TABLE OF LEADING ARTICLES.

The Growth of Electric Motive Power............ 275
Power Plant Instruction Books.................... 275
The Cause of the Quebec Bridge Failure......... 276
A Matter of Signals.................................. 276
The Substructure of the Dearborn St. Bridge, Chicago. (Illustrated) 278
Completion of the Cross River Dam, Croton Water-Works System. (Illustrated)...................... 281
British Power Plant Accidents in 1906............ 283
The McNulty Building, New York. (Illustrated)... 285
The Hydro-Electric Development of the Great Northern Power Co.—Part II. (Illustrated)......... 287
The New Water and Sewerage Systems of Manila. (Illustrated) 292
The Power Plant of the Elgin National Watch Works. (Illustrated) 294
The Erection of the Las Vacas Viaduct. (Illustrated) 297
The Circular Tanks at the Lancaster Filtration Plant. (Illustrated) 298
Canal Transportation in France.................. 299
The Vacuum Heating System in the Godfrey Block, Grand Rapids. (Illustrated)...................... 300
Electric Locomotives on the Pennsylvania Railroad.. 301
Book Notes 302
Unit Spiral Tables.................................. 302
The Cause of the Quebec Bridge Failure.......... 302

The Growth of Electric Motive Power.

Prof. S. P. Thompson's presidential address before the Engineering Section of the British Association, extracts from which were printed on September 7, contains a most interesting abstract of the history of electricity as a motive power. It is immensely difficult to set one's self back in viewpoint a half century and to look on the electric motor and its possibilities as they were then seen. In 1857 the machine was no novelty; it had in fact been known for at least a quarter of a century. At the beginning of that epoch there was precious little popular interest in electricity. It was unfamiliar to all save a few savants, and to them it was mainly of theoretical interest. But a few years later the advent of the telegraph waked the world to some appreciation of things electrical. The commercial needs of the growing art brought about the invention of improved batteries, and the study of the principles of electro-magnetism. An immense amount of active experimenting went on and so it came to pass that at just about the period mentioned by Prof. Thompson, that is, in the "fifties," there was in progress an active "boom" in electrical work, checked only by the lack of adequate sources of electrical energy. A great deal of clever invention work was being done, so much that many an incipient patent of to-day has received its quietus from the work of Page and his contemporaries. And it is worth noting that since that period there have been but few and slight improvements in the electric battery.

Lacking the dynamo, however, it is small wonder that even the most far-sighted should look upon the electric motor as of questionable practicability. There were those who even then held firmly to the belief that electricity would supersede steam as a motive power, yet the sounder judgment was of those who held that its chances were small on account of the uneconomical source of energy. Although to-day a million horsepower and more of motors are in regular use, the doubters of 1857 were essentially in the right. The steam engine is no nearer to being pushed aside now than it was then. The battery stands just where it did then—it was and is incomparably more costly as a source of power than the steam engine. Lord Kelvin, the sole survivor of the brilliant group that discussed electro-magnetic engines on the occasion referred to by Prof. Thompson, need not, fifty years after, retract a word of his early opinion. His contingent possibility has come to pass, that is all. It was a decade later that the beginnings of the dynamo were in evidence, and a score of years before the electric motor in the modern sense of the word made its appearance. And up to the present time the motor has been chiefly an immensely useful intermediary between the steam engine and its point of application. This statement points out the vast economic loss that is still part of our every day life. Although an electric motor of moderate capacity may have an efficiency as high as 95 per cent., mankind is still condemned to furnish it energy from a prime mover with an efficiency of only 10 or 15 per cent.

Electricity direct from coal is as far distant as it ever has been. The few carbon-consuming batteries devised have failed of any commercial usefulness and there have been no cheap batteries invented in the least able to compete with coal and engine. Perhaps the most interesting possibility in this line is the thermo-regenerative battery, thus far of only theoretical interest. This is merely a primary battery of which the current producing reaction is reversible by heat, just as in the storage battery it is reversible by electrolysis. Heat the battery and it goes back to its initial state ready for a new task. Perhaps some chemist may solve the problem and enable the heat of coal to be applied at an efficiency enormously greater than is possible with a steam engine, an efficiency perhaps as great as that of our present boilers. It will take some such revolutionary discovery as this to put the steam engine in some form out of business. The internal combustion engine we have, of course; but great as are its possibilities it has not yet pushed the steam engine hard in actual economy in spite of the fact that it has double the thermo-dynamic efficiency. The next few years should show great strides in the use of gas engines in large sizes, and also some material improvements in steam practice which will probably keep the steam engine still in active work. The electric motor is still the intermediary, though it has been pushed into use to an extent that even a dozen years ago seemed scarcely possible. The advent of the alternating current motor in its various forms has been the strongest recent stimulus in the art. If the great experiments in traction by alternating motors result favorably, the first important inroad on the absence of the steam engine as a working motor will have been made, but behind the motor and the dynamo will still be the engine and boiler, in spite of all. The engineers of the "fifties" were not so far wrong in their chief premises, after all; they merely failed to appreciate the importance of the flank movement which actually took place. And, truth to tell, it is often the flank movements in engineering that enable important positions to be carried in cases where a frontal attack might miserably fail. It is trained resourcefulness that counts.

Power Plant Instruction Books.

The complex operating problems present in many of the electrical industries demand clearly worded and carefully printed instructions in the form of small handbooks for the use of employees. Particularly in transportation service has this necessity become recognized, and the preparation of special books covering the operating exigencies of electrified terminal service is an outgrowth of the new conditions in the field of heavy electric traction. In the work of the New York Central in the vicinity of the metropolis, special instruction books have been prepared in connection with the operation of the high and low tension distribution systems, the maintenance of the third rail and its auxiliaries, and the operation of the new electric locomotives. The New Haven locomotives have also been made the subject of treatment in a small pocket book issued by the latter company. The detailed operation of power plants has not received this sort of treatment to any extent, though in the case of the New York Central sub-stations the printed instructions are very carefully worked out with reference to the maintenance of continuous service.

It is a question if the handling of very large power plants could not be considerably facilitated if the instruction book idea were applied to installations of high capacity and great responsibility of output. The operation of power plant machinery is, of course, a regular business or group of occupations in itself, and to a large degree men employed by a company for power house service are supposed to know the details of their work before they take an active hand in the operation of the equipment. But the facts usually are that the conditions in no two plants are alike, and especially in isolated installations supplying a great variety of service, perhaps including heating, ventilation and refrigeration, it is a matter of no little time for a new man to feel sure of his ground in the rapid handling of valves and switches. It would certainly be a distinct help if some equivalent of an instruction book or at least a type-written set of data expressing the main physical features and operating peculiarities of the system could be kept as a part of a complicated plant, being a sort of mechanical and electrical inventory of the equipment and its arrangement.

Small plants would not need anything like the fulness of instruction desirable in high-powered stations. The latter contain as a rule much more auxiliary apparatus; the exact responsibility and duties of each employee are more essentially specified, and in the case of very valuable machinery, the handling of it should become a matter of established routine, both in normal and emergency conditions as far as they can be anticipated. A clear statement of the functions of different main and auxiliary switches and valves, of the order of operations desirable in starting up a large generating unit and in shutting it down, of the proper sequence of moves in starting rotary converters and other apparatus, the routine of handling storage batteries—these and many other points carefully considered in a small instruction book would certainly save time in the breaking-in of new men, and in the maintenance of a higher mental efficiency on the part of more experienced employees. Amended from time to time such a book would represent the kernel of the best operating knowledge in that particular installation. No instruction book can take the place of an alert and intelligent employee at the switch or throttle in times of crisis, but if stripped of the dead wood of long-winded descriptions of standard machinery and packed full from cover to cover of practical operating points it would be a most valuable aid to high efficiency of personal service in large and complicated installations.

The Cause of the Quebec Bridge Failure.

Up to the present time nothing has been discovered which in any way adds any essential information regarding the condition of the wrecked Quebec bridge to the statement published in the news section of this journal last week, nor has the inquiry by the coroner developed any facts not given then. It is not at all surprising that this is the case, for the nature of the accident was such that the wreckage cannot be expected to contribute any definite information save that the material and workmanship were of the highest character. Engineers who visited the wreck agree fully on this point. In view of the special care taken in testing, fabricating and inspecting the material any other conclusion is untenable, and those acquainted with this work are fully convinced that the examination of the twisted and distorted ruins will confirm this opinion. While it is desirable that a thorough detailed examination of the fallen portion of the structure should be made, it will be most improbable that the cause of the accident will be discovered there. It is also possible to discard the horrible suggestion that the accident was due to the malicious acts of persons with some fancied grievance against the builders, for it is inconceivable that the structure should have failed as it did if the accident were due to such a cause.

There is little reason to believe, however, that the cause of the accident will remain undiscovered, which would be an engineering calamity greater than the collapse itself, but there is ground to expect that some theories or methods of bridge engineers will be modified. Engineering is not an exact science, but a highly developed craft, so highly developed as to merit the dignity of a profession. It closely resembles medicine in this respect. Thousands of people died from what physicians termed diseases of the alimentary tract before the nature of appendicitis was determined, and knowledge of this disease is so recent that it lends particular emphasis to the point to be made. Nobody lost confidence in the medical profession when it became known that failure to discover earlier the nature of appendicitis had been responsible for great suffering and countless deaths. On the contrary, people rejoiced at the progress that medicine had made. Engineering is precisely like medicine, except that its weaknesses are blazoned abroad while its achievements are overlooked. It is universally known that a physician has to make assumptions in connection with his diagnosis; but it is not so well known that the engineer also has to make assumptions, and that about the only way he can know that these assumptions were wrong is through the results which his works produce. The accident at Quebec demonstrates that something was wrong, and while there is a possibility that this weakness will be found by a search through the ruins it is also possible that it will be discovered by a critical examination of the design. This statement is no reflection in any way upon the work done by the engineers connected with the Quebec bridge, for that structure was the result of the careful study of men widely recognized as careful, thorough and competent. It simply means that in making that design, like the design of every large bridge, many assumptions had to be made regarding the distribution of stresses, and it is possible that these assumptions did not recognize all the features of the details of the design that affected the stresses.

It is noteworthy that among the suggestions regarding the cause of the accident that have been made by structural specialists to The Engineering Record the unforeseen influence of secondary stresses is advanced more often than any other possibility. The letter on the subject printed elsewhere in this issue is an example of these opinions, and this particular letter, it might be added, was written only after a computation had been made and checked to confirm the views stated regarding secondary stresses. There is hardly a subject connected with the design of steel work which is the subject of more controversy than this. In fact the difference in the views held regarding it is well shown by the fact that the eminent specialist whose computations are stated in the letter should reach a result so different from that of the engineers who designed the Quebec bridge. For this reason it would be eminently proper for the American Society of Civil Engineers to follow the precedent it established in the case of the Johnstown dam failure and appoint a committee to investigate the cause of the Quebec bridge collapse. While the engineers who are officially connected with the investigation now in progress for the Dominion government will doubtless discover valuable facts, the kind of an investigation that is most needed is one that can be made only by a very carefully selected committee of the American Society of Civil Engineers acting solely in the interests of engineering. The expense of such an investigation will be considerable, but the Society could do no better work for its members and for the public which relies on its members' abilities than to conduct a thorough examination of this sort. In making this suggestion The Engineering Record repeats that until such a strictly professional investigation is made the cause of the disaster will not be definitely known, and it may not be then. It fully recognizes the importance of secondary stresses, but it wishes to have the most positive and complete data regarding them in this case before accepting them as the real cause of the disaster. As a rule, secondary stresses are much more dangerous in tension than in compression members, which seem to have been the first to give way in the Quebec bridge. The deflection of the lower chord section of the anchor arm near the main pier, which was noticed by an inspector some time before the accident, may have been due to a weakness of some sort rather than to secondary stresses, and it would not be surprising, when all the facts are known, to discover that the failure was due to a cause whose main element was not secondary stresses.

There is one element of the accident which leaves no ground for debate, however, and that is the importance of stopping work and ordering men off a structure as soon as any sign of buckling is seen in a compression member. It is customary for bridge erectors to look upon small deflections without much consideration as to what may be their cause. These deflections are seen so often and so very rarely cause any trouble in small structures that their significance is not appreciated in large bridges. The deflection observed in the lower chord of the anchor arm in the panel next the main pier was probably the result of the final weakening of the resistance of the structure to the forces that produced its collapse, and with this incident as a precedent it is to be hoped that hereafter any such signs will be considered a signal for an immediate investigation of the most thorough nature.

A Matter of Signals.

A curious controversy has recently been vexing the pages of a contemporary, "Science," regarding some questions of physiological optics involved in railway signaling. It had its origin in a so-called "popular" article in the "Century," and has now degenerated into that singularly fruitless academic hair-splitting to which the professional mind seems prone. The main issue has been quite lost in the shuffle and the disputants are too busy hurling citations at each other to hunt it up. Now "popular" scientific articles in the magazines are, as a rule, by no means badly done, although they can seldom withstand the ingenious analysis of the petty controversial mind. It is next door to impossible in matters of physical science to make a definite and unqualified statement in plain intellectual English which is not open to attack for some inconsequential sin of omission or commission. In the case in hand the original author laid down the proposition that on account of the inefficiency of the eye in judging colors in weak light it would be wise to substitute for colored signal lights a system which should show the condition of the track by the position of luminous lines. In other words, since color signals are for certain definite reasons liable to be confused, let us try position signals which are free from the faults under consideration. Whether as a matter of practical railroading the proposed system would prove advantageous one can hardly say offhand, and it is safe to assume that the railroads would not change generally to this or any other improved system save under dire compulsion, because changes cost money.

Unhappily the writer of the "Century" article expressed himself somewhat carelessly and left several possibilities of misinterpretation which a Western professor pounced upon like a hungry cat upon an incautious mouse, and immediately those who were watching the affair found themselves in trouble. Experiments in physiological optics are rather discordant and indefinite at best, and the subsequent controversy, although rich in something very like the "odium theologicum," has been poor in every day facts to which the engineer can pin his faith. Now the matter of dispute, in so far as it concerns signals, is in theory quite simple. The human eye sees color very badly when the source of light is weak, not at all if it be very weak. Whether the "dark-adapted" eye can distinguish color as well, or a hundred times as well, as the "light-adapted" eye cuts little figure when it is notorious that neither sees well enough to work successfully when the source of light is very dim.

If the eye be color blind in the usual form of red-blindness, wholly or partially, the regular red signal light will prove comparatively inefficient and even if one has normal color vision his judgment of a very faint signal light may be tragically wrong. The usual signal-red glass lets through not only red, but orange, yellow and even a little yellow-green, and seen at a distance or through mist the red, even to the normal eye, pales, through the low luminosity of the full red, until the apparent color may change considerably. Thus a red lighthouse flash sometimes loses its characteristic color long before it ceases to be seen as a light. Any other strongly colored light, if likewise of impure color, is subject to analogous change as the luminosity decreases. That the failure of the color sense in very dim light has caused serious accidents can hardly be doubted. As regards position signals thev can, if of adequate dimensions, be seen as long as the lights are visible as lights and long after all color values have disappeared.

The main contention for a position signal as against a color signal as giving better visibility is unquestionably sound. Whether a change in practice is feasible, and if so what should be the form of the position signals, are questions not so readily answered. As the speed of trains has increased there is increasing need of signals capable of being clearly distinguished for a very long distance. The practical trouble is that the necessary distance which is approximately the braking-distance of the train, is very much greater than the penetration of any signal light now in use. In a fog a few hundred feet distance will render the lights totally invisible, whether one or many, white or colored, while to be of much use a signal should be distinct up to at least a thousand yards. It is rather doubtful whether any visual signal can be made effective enough to meet this condition and the final result may well be an entirely different solution of the problem. Audible signals or electrical signals delivered directly in the cab, or even a positive automatic block system may be the final recourse. Any of these offers a far better chance of real safety than visual signaling. In earlier days, when train speeds were usually low and the trains themselves were light, the situation was simpler. Every train, like every electric car, must be considered as carrying before it a dangerous space equal to the braking distance, within which lies peril. For an electric street car this distance may be one or two hundred feet; for a fast and heavy train one or two thousand yards. If warning of danger is not conveyed from ahead of this space, an accident cannot be averted. Most of the recent appalling collisions are due to disregard of this exceedingly simple fact. There is no excuse for neglecting to provide signals of some kind capable of spanning the dangerous space. If lights and semaphores fail, then it is high time to try something else. The frightful casualty list on our American railroads bears witness of the need for immediate action.

Notes and Comments.

The City of New York like other bodies of a corporate nature has been suffering during the summer from a serious difficulty in obtaining ready cash. Some contractors have been forced to receive payment in bonds at par which were sold subsequently at a lower rate which made them an unsatisfactory form of payment and seriously reflected on the credit of the city. This condition has been heralded far and wide as indicating the immediate descent of hard times upon the entire country; consequently it is most encouraging to observe that a sale of bonds held this week in New York resulted in a subscription of five times the amount of the issue. The city offered $40,000,000 4½ per cent. gold bonds and for them over nine hundred bids were received, aggregating $207,159,420. Two of the bids were for the entire issue. All the bonds will be sold considerably above par, and the result of the sale, the largest of the kind ever held in the city, shows that the financial troubles of the summer just passed were due to temporary conditions that are now a thing of the past.

An Engineering Feat deserving mention has been accomplished by the undergraduate engineers of the Colorado Agricultural College. This was running a line of levels to the top of Long's Peak, which for many years it was thought impossible to ascend. The upper part of the peak is an immense granite boulder, about half a mile long and 500 ft. high. On one face is a precipice of 2,600 ft. The ascent was finally made by starting on the northeast corner and passing completely around the peak, part of the way on a narrow shelf, and finally reaching the top in a crevice on the southeast corner. The students connected with a bench mark of the Union Pacific Ry. in Estes Park, and ran a duplicate level for a total distance of about 16 miles horizontal distance, and nearly 7,000 ft. vertical difference of level. Since then the U. S. Geological Survey has run a double line of levels, one via Longmont and one via Loveland, connecting with the work on the plains, and finally with the line of precision levels of the U. S. Coast Survey. The height of the peak as finally determined, is 14,255 ft. above sea level. The work of the Hayden survey has universally been recognized as being very good. This is shown by the fact that the elevation of the Peak as given by Hayden is 14,274 ft., a difference of only about 19 ft. in elevation. Long's Peak is probably the only peak besides Pike's Peak, where a line of spirit levels has been run to the top. There is no comparison in the difficulty of ascending and running levels over the two peaks.

The Excavation Progress that is being made on the Panama Canal is decidedly encouraging to those who hope to see the work completed within the time anticipated by those responsible for the adoption of the high-level plan. During the last month the total amount of excavation was 1,274,000 cu. yd., the largest record yet made, and as this volume was excavated during one of the most rainy months of the year, it is safe to assume that a still larger amount will be taken out during most of the other months. Hence it seems fair to believe that the excavation will be carried through to completion in less than seven years from the present time, when all the steam shovels now under construction are delivered and the tracks for spoil are completed. The figures recently received from the isthmus show how completely misleading were the statements sent North by newspaper correspondents a few months ago regarding the demoralization of the working force on account of the administration's determination to place the control of the work in the hands of eminent members of the Corps of Engineers of the army. At the present time the only feature of the work which foreshadows any probability of trouble is the construction of the dam and lock at Gatun, and unless definite unfavorable information is received concerning the condition of the works in question the excellent showing made last month by Colonel Goethals and his staff warrants the public in anticipating that the time of doubt and uncertainty regarding this great undertaking is now past.

The Two-Cent Fare Legislation of Pennsylvania received its first judicial setback recently in the Philadelphia Court of Common Pleas, which decided that the law was unconstitutional. Of course this decision was made in a minor court, and until it is settled by courts of final jurisdiction the matter will remain in dispute. Nevertheless it is interesting to see that the law has been rejected, not only as being a violation of the Pennsylvania Constitution, but also as violating the Federal Constitution, in that it is confiscatory in character. If this opinion is confirmed by the highest Pennsylvania court it is safe to say that those of other States will take a similar view of the matter when it is brought before them, except in a few cases where the State judiciary has long been decidedly averse to the fair treatment of capital invested in public service undertakings. It is also necessary to bear in mind that the sweeping general laws regarding rates which were put on the statute books in some States recently may produce a very nice legal situation that was not brought up in the Pennsylvania case. It may be found in a few States where the constitutionality of these laws will shortly be before the courts that some roads have actually benefited by the greater amount of traffic resulting from the lowering of the rates. On the contrary a minor road may show a loss. In view of such a situation, the futility of any general attempt to regulate rates by law will become evident. What has helped one company has injured another, and it is entirely possible that some of the minor companies may be forced into bankruptcy by legislation of this character. The problem is a complicated one, and as it vitally affects a large amount of engineering work held in abeyance until the troubles are settled, it behooves engineers to give it their most careful consideration.

The Fire Hazard of lofty office buildings was the subject of dire prophecy by the president of the New York Board of Fire Underwriters at a recent meeting of the building code revision committee of the New York Board of Aldermen. According to this fire insurance specialist, with the present unlimited height of buildings in the financial center, where the streets are being converted into canyons by the walls of lofty structures, a great disaster exceeding any ever yet experienced is being courted. It was asserted that the San Francisco fire showed that so-called fireproof buildings cannot withstand the attacks of a great wave of flame. Fire underwriters were stated to anticipate that a fire starting in a group of lofty buildings would be beaten across the narrow streets from the windows on the top floors, and no system of sprinklers or fireproofing would avail in the least to prevent the spread of conflagration. Firemen down below in the narrow streets could accomplish nothing. With respect to this utterance, which is not at all unlike those previously made by fire-underwriters, it is necessary to point out in the first place that gentlemen engaged in the insurance business naturally take the gloomiest view of the probability of the spread of a fire. It is their duty as well as their business advantage to preach the utmost completeness in provision against the spread of a fire. In the second place, there seem to be ample reasons for the belief that the protection afforded by a well-built and properly equipped office building against the spread of fire is something generally unrecognized. For example a good many years ago in the City of New York, the Home Insurance Building unquestionably prevented the spread of a serious fire in the downtown business district. The character of the office buildings in respect to their resistance to the spread of a fire is really more under the control of the insurance interests themselves than under that of the city. The building laws formulated by a city must always, of necessity and equity, prescribe minimum requirements consistent with reasonable safety and sanitation. It is out of the question for the city to demand the character of construction which insurance people consider best suited to prevent the spread of such fires as those under consideration. The insurance interests themselves, however, can materially advance the cause they have at heart by an adjustment of their rates which will make it more desirable for building owners to erect structures of the highest resistance to fire.

THE SUBSTRUCTURE OF THE DEARBORN STREET BRIDGE, CHICAGO.

The Sanitary District of Chicago is increasing the width of the Chicago River and the South Branch of that river to 200 ft., and the depth of the main river and this branch to 20 ft. below Chicago datum, the latter being about 1.5 ft. below the mean stage of water in the river. This undertaking has already involved a large amount of difficult and expensive construction work, included in which is the replacement of the old centerpier highway drawbridges with bascule bridges. Eleven of these new bridges have been completed and are in service, and still more remain to be built. A minimum clear channel width of 142 ft. inside protection cribs for the piers is provided at the new bridges, while a bypass back of each pier increases the cross-section of the waterway at the crossings to nearly the same as that of the standard channel width and depth.

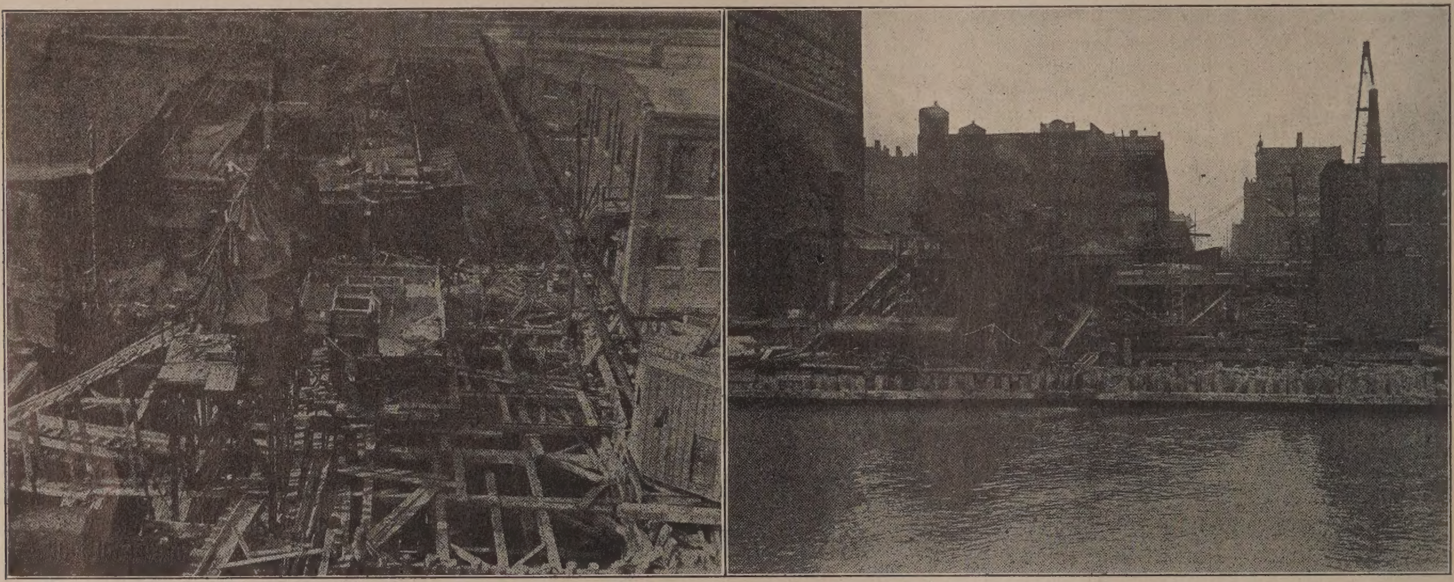
The bridge across the main river at Dearborn street, which will soon be opened for service, is one of five bridges which carry the great volume of traffic between the North side of the city and the central business district, and also the cross-town traffic between the North and South sides. This traffic has all been confined to four bridges for two years, since the old Dearborn street bridge was torn down, with the result that all of these bridges have been badly crowded during rush hours. The new bridge will, therefore, greatly relieve the present situation, and particularly so with regard to the provision of an additional outlet for street railways from the central business district. It is a double-leaf Scherzer rolling-lift bascule bridge, having a clear span of 164.5 ft. between the centers of the front bearings, and providing a 36-ft. roadway, with a 10-ft. walk on each side.

Each leaf of the bridge is carried by a heavy reinforced-concrete abutment, which forms the front wall of a large sub-structure containing a by-pass waterway, two pits for the counterweights and a pit for the floor of the leaf. The two sub-structures of the bridge are the same in general design. They are each 48.5x67 ft. in extreme dimensions in plan at the top and rise to a height of 29 ft. above their footings. The abutment carrying the front bearing of the leaf and the front end of the track girders for the counterweight is 8 ft. wide at the top and is battered 1 in. to the foot on both sides. Back of this abutment is a by-pass, 8 ft. wide at the bottom, which extends through the sub-structure, normal to the axis of the bridge. The counterweight and floor pits are separated from this by-pass by a heavy concrete wall, the counterweight pits having an irregular shape in transverse cross-section, corresponding with the shape of the counterweights. The sub-soil conditions at the site were such that it was necessary to build each sub-structure on twenty 6-ft. circular concrete columns carried down to rock, or to material affording a good foundation. Most of these columns extend from 95 to 105 ft. below the mean water level in the river, and are designed to carry practically the entire weight of the sub-structure and the load on the latter.

The river bottom at the site of both sub-structures is soft river silt to a depth of 7 to 14 ft., under which is a soft plastic blue clay that extends down 40 to 45 ft. below the mean water level in the river. This clay has about the same consistency as putty containing a surplus of oil and has very little capacity for carrying loads unless thoroughly confined. Below this plastic clay, are various strata of a stiffer clay, and of hard, brittle clay, until hardpan is found at about 65 ft. below Chicago city datum. From this hardpan down nearly to bed rock is a material generally termed miners' loam, which when dry is hard and brittle, but when wet has much the same nature as quicksand. The bed rock is about 95 ft. below the water level on the south side of the river, but drops away to a depth of 105 ft. below that level on the opposite side. Immediately overlying the rock, between the latter and the miners' loam, is a stratum of quicksand of varying thickness, which contains a large amount of water and is filled with gravel and boulders.

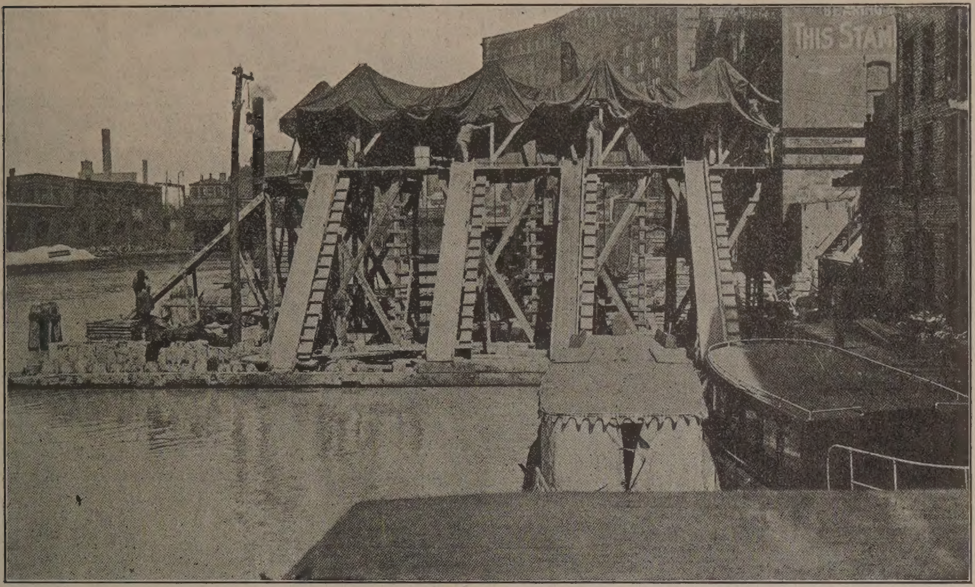
In addition to these peculiarly difficult soil conditions, two brick-lined tunnels for gas mains had been built under the site approximately parallel to the center line of the new bridge and at a depth of 31 to 43 ft. Both of these tunnels are on the same side of the center line of bridge. One of them is 6 ft. in diameter, and the other has an elliptical cross section, with axes of 5 and 7 ft., each tunnel carrying a 30-in. gas main. The location and profile of these two tunnels are shown in an accompanying illustration, from which their proximity to the concrete columns carrying the sub-structures may be seen. The pipes in these tunnels are important feeder mains that had to be kept in service at all times while the work was in progress.

Owing to these local conditions and limitations, the construction of both sub-structures was handled with considerable hazard. After the draw span of the old bridge on the site had been floated away on scows to another location, the center pier and the crib-work protection for this pier were removed and the channel dredged to about the established standard depth of 20 ft. The two rest piers of this span were also taken out, meanwhile, the intention being to build both sub-structures for the new bridge simultaneously. It was considered, however, that the proximity of the protection of the draw span of the Clark street bridge, a block downstream, would interfere with traffic in the river if cofferdams for both sub-structures were built at the same time. Accordingly, a cofferdam enclosing the site of the south sub-structure was built first and the latter completed; this cofferdam was then removed and the one for the substructure on the opposite side built.



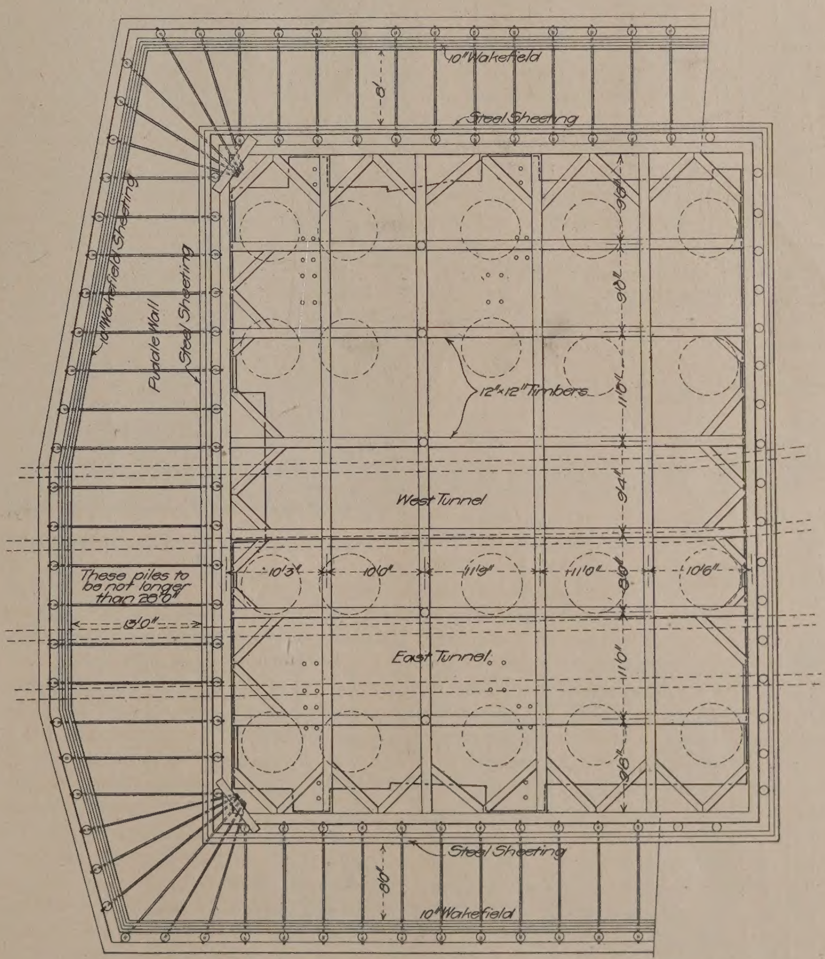
Two Views of North Cofferdam Showing Head Hoists, Concrete Mixing Outfit and Other Construction Plant.

The details of one of the cofferdams, which were both generally the same, are shown in one of the accompanying illustrations, each cofferdam unwatering a space 53x64 ft. in plan. The treacherous soil conditions and the location of both sub-structures outside of the dock lines required all four sides of each site to be enclosed. Each of the three sides in the river had on the outside a row of heavy round timber piles, against which was a row of triple-lap Wakefield sheet piling made of 3-in. plank; and on the inside, a second row of heavy round piles, against which was driven a row of Friestedt interlocking channel-bar steel sheet piling. The space between the two rows of sheet piling on the ends of the cofferdam was 8 ft., while on the river side this space was increased to 13 ft. over the tunnels as shown in the plan. The space thus enclosed was filled with clay to make the cofferdam watertight. The round piles were in 30-ft. lengths, and were driven to a penetration of 10 ft., except over the tunnels where care was taken to avoid penetrating the latter. The wooden sheeting was in 30-ft. lengths and was driven to about the same penetration as the round piles. The steel sheeting had been used previously in four cofferdams, but was still in good condition. It was in 40-ft. lengths, which were driven to a penetration of 6 to 8 ft. more than that of the wooden sheeting, except over the tunnels. The land side of the cofferdam consisted of a close row of heavy round piles, tied together with waling pieces so as to form a footing for the bracing used in the cofferdam.



Head Hoists on South Cofferdam.

In building each cofferdam the inner row of piles and steel sheet piling were driven around the three sides in the river with a floating pile driver. After the completion of this work the outer row of piles and sheeting were driven by the same driver and the enclosed space filled with clay by a dredge. The water in the cofferdam was then slowly pumped down, in order that the system of heavy cross-bracing might be placed. This bracing was in four horizontal planes, one just below the top of the piling, and the next three spaced 6, 4 and 3 ft. apart on centers, respectively, from the top down. The bracing consisted of 12x12-in. timbers, placed in regular transverse and longitudinal rows, the sets in the different horizontal planes being braced apart with vertical posts. In both cofferdams the river bottom was considerably higher at the back of the cofferdam than at the front, so in order to permit the bracing to be placed regularly, the excavation was started as soon as any of the bottom had been exposed by pumping. This excavation was made by shoveling the material into buckets and hoisting the buckets out with a turntable derrick crane mounted on one end of the cofferdam. When the cofferdams were pumped out the head of water against the face on the river side was from 20 to 22 ft. The cofferdams stood throughout the work without accident, however, although a portion of the river side of the north one directly over the tunnels was pushed in to some extent, but the steel sheeting prevented a failure at this point. A pulsometer pump was capable of keeping each cofferdam free from water, and during most of the time was not worked to its full capacity.



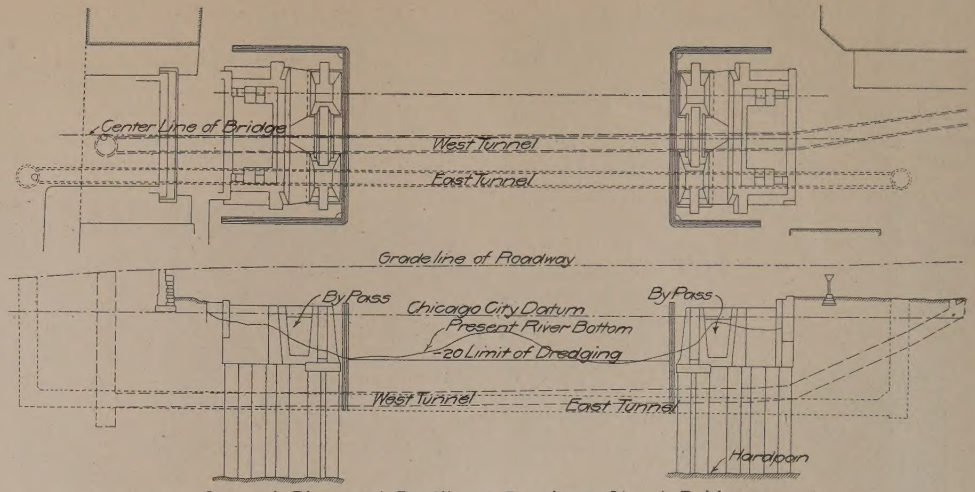
Details of Cofferdam for Dearborn Street Bridge.

After the material in the bottom of the south cofferdam had been excavated down to a depth of 18 ft. below the water surface in the river, work was started on the excavations for the concrete columns. The latter are in four rows of five each, two rows toward each end of the sub-structure. Each column was built in a separate circular well, according to the same general method employed in building similar columns for footings for large buildings, as is regularly done in Chicago. Five of these wells were opened up at a time, the four inshore ones in the row at one end and the offshore well in the adjoining row being sunk first. The well in the outer corner of the cofferdam was thus left until these first five had been finished and the concrete columns built up in them; this well and the four in the second row were next opened and columns built in them. The same program was then carried out with the ten wells under the other end of the sub-structure.

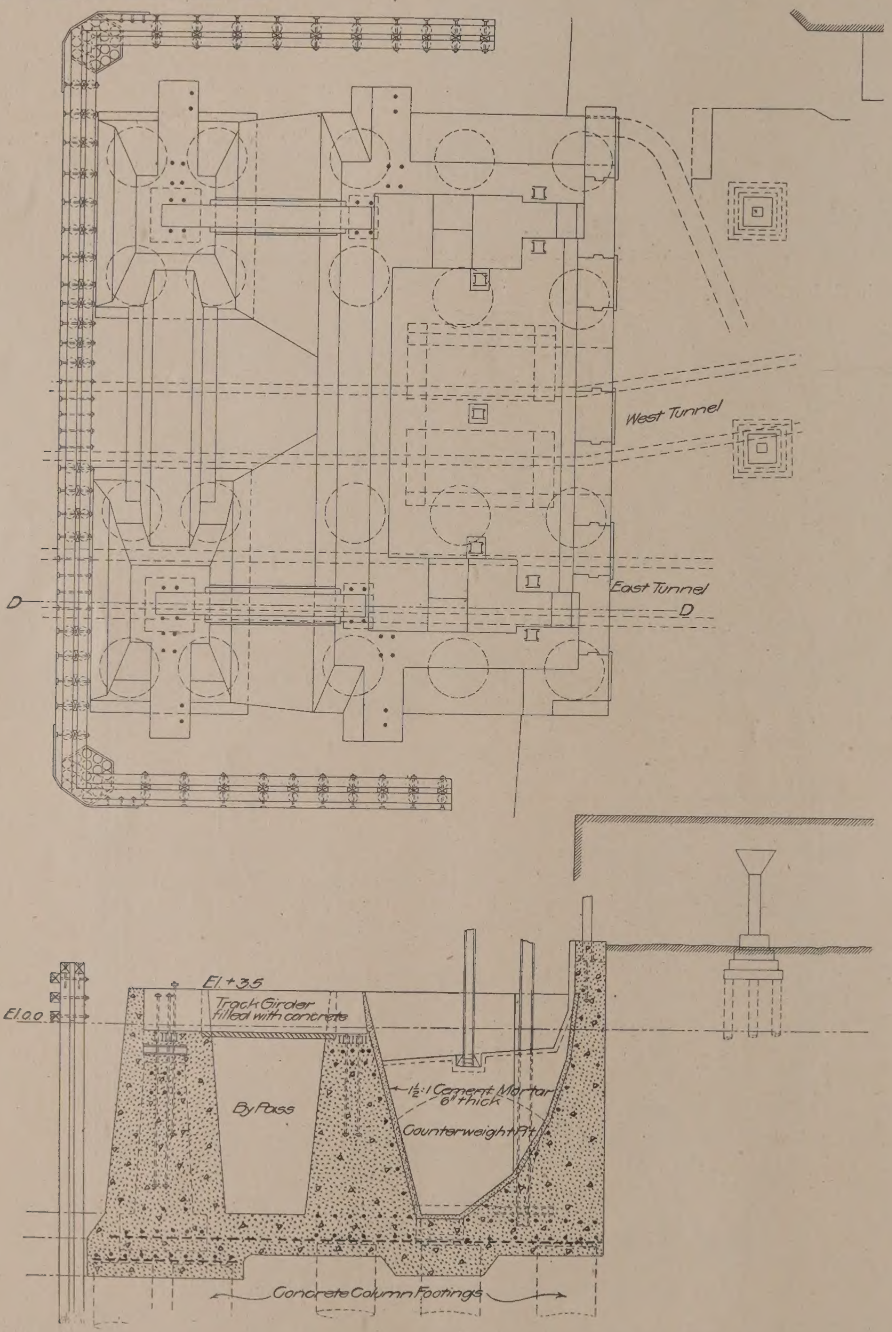
In the greater part of the wells, 3x6-in. tongue and grooved plank were used for sheeting; 3 and 5-ft. lengths were employed, depending on the character of material, two steel lagging rings being placed to each set of planks. In driving through the sand boulders and water overlying the rock, it was found necessary to use steel cutting shields for a distance of 14 to 17 ft. These shields were each made up in four parts, the cutting section being 5 ft., and the remaining sections 3 ft. long. They were built of 5/8-in. plates, reinforced with two 2-in. angles. The sections were assembled in the well and the shields forced down to rock by means of jackscrews bearing on bulkhead timbers placed across the well. The excavation was all made by hand, the material being hoisted out in buckets.

Five separate, portable head-hoist platforms were built when the excavation of the wells was started, one for each of the wells that had been opened. These platforms were each 10x10 ft. in plan and were placed on a cross and sway-braced four-leg tower, 20 ft. high. A small tripod derrick was erected over each platform. These derricks carried a block at the top, through which a hoist line was passed to a hoisting spool at the base of the derrick. These spools were driven by an endless wire cable, which was driven in turn by a hoisting engine. The cable passed along the row of towers, and through the hoisting spools at each of the latter, the arrangement being such that buckets could be hoisted independently from any one or all of the wells. An opening large enough to pass a heavy bucket was left at the center of each platform, the tower for the latter being set on the top bracing of the cofferdam and directly over one of the wells in which the excavation was in progress. Two men were required on each platform to handle the hoisting line and to dump the buckets when the latter reached the surface. The materials brought up on each platform were dumped from the buckets on a flume leading down to the water just outside the cofferdam, these flumes being steep enough so the clay would slide on them. The materials from the wells were dumped into the river at the ends of the sub-structure in this manner and were later dredged out and hauled away in scows when the cofferdams were removed. After the five wells of the set had been finished, the head hoist platforms were picked up by the turn-table derrick crane and moved to the next position, or were moved across the bracing on rollers.

The concrete for the wells and also for the sub-structure was made in the proportions of 1 of cement, 2½ of sand and 5 of broken stone. All of it was made in a pug-mill mixer set up on the fourwheel wide-gauge truck of a turn-table derrick. Charging hoppers for the mixer were erected over the latter, a working platform being built around these hoppers. The mixer outfit was brought to the work on a scow and then run out on rails laid on the bracing of the cofferdam. Materials were supplied to it from scows by either of two turn-table derricks, both placed on the ends of the cofferdam. The concrete was delivered from the mixer directly into chutes and pipes leading to the bottom of the wells. As soon as one set of wells was completed the mixer outfit could readily be turned so as to deliver to the next set.



General Plan and Profile at Dearborn Street Bridge.



Plan and Cross-Sectional Elevation of North Substructure.

When the wells and sub-structure on the south side of the river had been finished, the whole construction plant was moved to the other side of the river, where the work was handled in practically the same way as on the south side, and in nearly the same sequence. The wells in the south cofferdam reached solid rock at a depth of from 90 to 95 ft., and, with the exception of considerable water in the quicksand directly over the rock, no particular difficulty was experienced in sinking them. In the wells of the north cofferdam, on the other hand, rock was not found until a depth of in the neighborhood of 105 ft. below the water in the river had been reached. Water was encountered in great quantities in the quicksand at this depth, but three wells were sunk to the rock and filled with concrete. As additional pumping from the wells might have caused damage to adjacent structures the decision was then made to increase the cross-section of the footings of the balance of the wells at a depth of about 64 ft., where hardpan had been found, and to form an elliptical 12x16-ft. base at this level for each column.

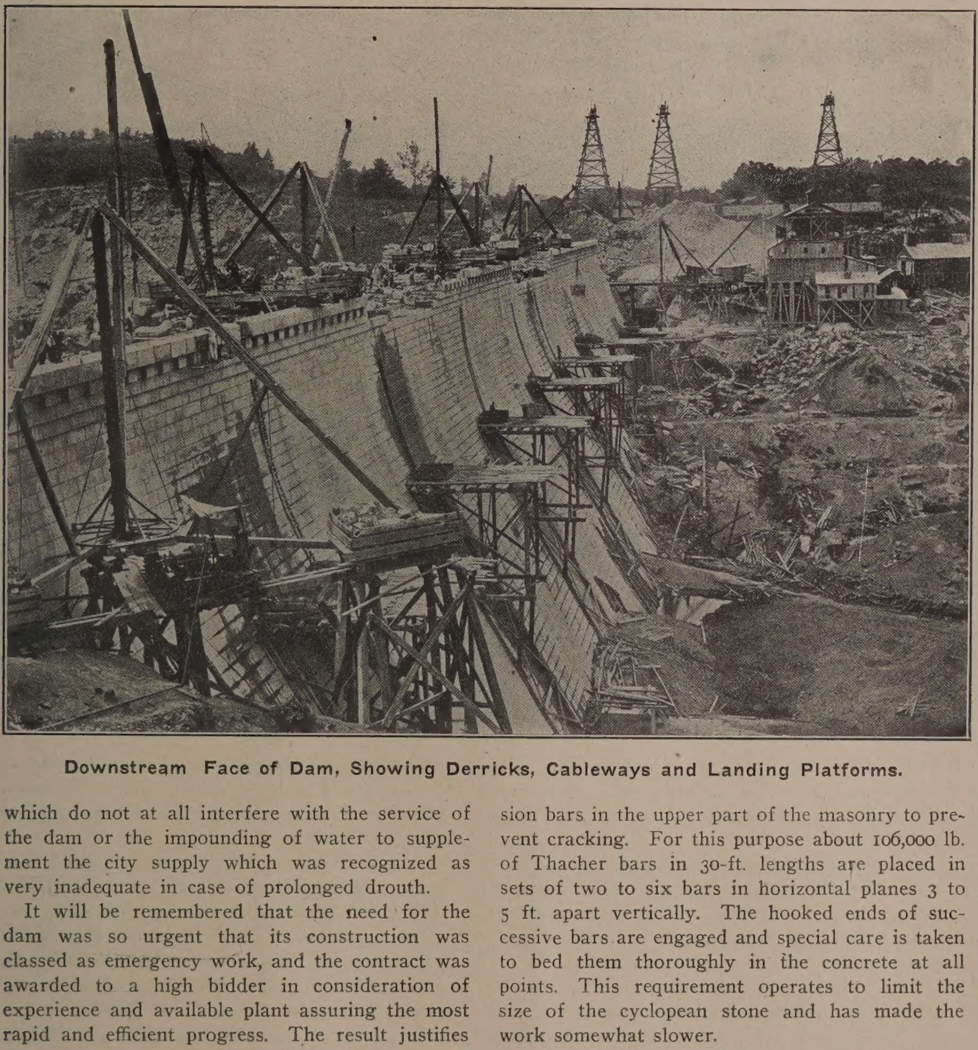
The two tunnels for gas pipes which pass under both sub-structures required very careful work in sinking the wells for the concrete columns. One of the tunnels is between two rows of columns under each sub-structure, and the two are so close together under the south sub-structure that there was barely room enough to sink wells between them. The work was completed, nevertheless, without materially injuring either tunnel, although one of them, which was lined with a single ring of brick laid in lime mortar, filled with water after the south cofferdam was flooded. The cofferdam was, therefore, pumped out again and the tunnels were filled with concrete from shaft to shaft.

The plans for the Dearborn street bridge were prepared by the engineering departmnt of the Sanitary District of Chicago, and the construction work was carried on under the supervision of that department. Mr. C. R. Dart is bridge engineer for the District. Mr. R. I. Randolph was resident engineer on the work. The old bridge was removed and the sub-structure of the new one was built by the Great Lakes Dredge & Dock Co.

Run of Mine Coal has been used successfully in the Chicago pumping stations, where formerly it was the practice to employ only lump coal which was supposed to have passed over 1¼-in. screens at the mines so that all pieces under that size were screened out before shipment. This made the coal more expensive, but theoretically it should evaporate more water per pound. By using run-of-mine instead of lump coal the average price was cut down from $2.55 in 1905 to $2.38 in 1906. In 1905 it required at all pumping stations 15.97 lb. of coal to pump 1,000,000 gal. to a height of 1 ft., while in 1906 it required but 15.026 lb. for the same duty, or 0.498 lb. less than in 1905. The total cost of pumping 1,000,000 gal. 1 ft. high in 1906 was 3.89 cents, while in 1905 it was 4.25 cents, showing a saving of 0.36 cent. Of this amount 0.25 cent was due to a saving in coal and 0.11 cent to saving in other causes. The Municipal Division of Tests and Inspection is making the tests.

Completion of the Cross River Dam, Croton Water-Works System.

The contract for the Cross River dam, near Katonah, N. Y., which is to impound about 9,000,000,000 gal. of water for the increased supply from the Croton valley for New York City was awarded, June 23, 1905, to MacArthur Brothers Co. and Winston & Co., for $1,246,211.60. The time limit of 26 months required the completion of the work on August 23, 1907. The time lost by the cessation of work due to an injunction served on the contractors soon after their organization was well completed, and in the reorganization and collection of a large number of employees in a difficult season of the year together caused a delay estimated to be equivalent to five or six months. Notwithstanding this gratuitous interruption, the work is now essentially completed except final touches and auxiliary construction like roads and bridges which do not at all interfere with the service of the dam or the impounding of water to supplement the city supply which was recognized as very inadequate in case of prolonged drouth.



Downstream Face of Dam, Showing Derricks, Cableways and Landing Platforms.

It will be remembered that the need for the dam was so urgent that its construction was classed as emergency work, and the contract was awarded to a high bidder in consideration of experience and available plant assuring the most rapid and efficient progress. The result justifies the unusual action and should be a source of satisfaction to the city of New York, its engineers and the contractors.

The design of the dam was specially adapted to expedite its construction by the use of moulded concrete blocks instead of cut stone in the face of the dam and the contractors' determination to make good their responsible undertaking installed a combined system of multiple cableways and derricks and provided an equipment far more extensive and expensive than is usually considered adequate for much larger works. With it they have been able to lay masonry at the rate of 18,500 cubic yards per month on a comparatively small area and have essentially completed the main dam, including excavation, diversion work and other preliminaries, in about 20 months working time, inclusive of about six weeks' delay through stress of weather.

The main part of the dam is about 900 ft. long and 170 ft. in extreme height, with a width of 23 ft. under the coping and 115 ft. at the widest part of the base. Its foundations are carried down to solid rock at a maximum depth of 40 ft. below the original low water level of the river. Both faces of the dam are battered except the upper part of the up-stream face which is vertical. It is built of cyclopean masonry faced with large moulded concrete blocks. The principal quantities involved are about 117,000 cu. yd. of excavation and 155,000 cu. yd. of masonry. The details of design, the plant installed and the methods adopted for the execution of the work have been described in The Engineering Record of May 20, 1905, June 16, 1906, and January 5, 1907.

Since these articles were published the design has been modified by the introduction of several horizontal tiers of continuous longitudinal tension bars in the upper part of the masonry to prevent cracking. For this purpose about 106,000 lb. of Thacher bars in 30-ft. lengths are placed in sets of two to six bars in horizontal planes 3 to 5 ft. apart vertically. The hooked ends of successive bars are engaged and special care is taken to bed them thoroughly in the concrete at all points. This requirement operates to limit the size of the cyclopean stone and has made the work somewhat slower.

It has also been decided to carry a 22-ft. roadway on top of the dam, and a 6-in. concrete pavement, crowned 3 in., is laid between the coping stones and is separated from the cyclopean masonry which supports it by a layer of tar paper. The pavement is pitched to five cast-iron catch basins in each gutter, which deliver through transverse 6-in. cast-iron pipes to a 12-in. cast-iron longitudinal pipe, pitched 1:100, which discharges into a cesspool beyond one end of the dam.

In order to handle supplies and machinery as rapidly as possible the contractors built a standard gauge track about 1½ miles long, with heavy cuts and fills and several trestles and bridges, to connect the dam site with the Harlem River Railroad at Katonah. The waters of the Cross River were diverted from the dam site by two earth and rock fill dams across its channels about 1,200 ft. apart. Between the dams the flow of the river was carried in a wooden flume and two 5-ft. riveted steel pipes about 90 ft. long, the latter being built permanently into the dam masonry. Excavation was made by pick and shovel and by blasting, and the spoil was handled successively by wheelbarrows, carts, bottom dump wagons, wooden skips and steel buckets, the latter being hoisted first by derricks and afterwards by cable ways.

Quarries were opened in the hillsides at both ends of the dam, and the larger stones were used for the cyclopean masonry, while the remainder were crushed for concrete, thus utilizing a very large proportion, estimated at 95 per cent. of the total amount of stone quarried. A 700-ft. and an 800-ft. cableway, transverse to the axis of the dam with their towers on opposite sides of the center line were installed to handle the excavated material from the pit and for the back fill, and were moved parallel with themselves several times to command the differet parts of the excavation. Three 1,300-ft, 15 and 18-ton longitudinal cableways with traveling towers were installed on high level tracks on both sides of the valley at the ends of the dam and commanded its entire area. The cables have a clearance of 25 ft. above the finished crest of the dam and, together with nearly a score of derricks have handled all materials.

A power plant was located on the south side, and in it were installed steam boilers of about 1,000 h.-p. capacity, an electric plant and an air compressor plant of about 1,120 h.-p. capacity furnishing power for the operation of all of the machinery. Two stone crushers located on the bank above the south end of the dam receive stone from the quarries, and after it is crushed deliver it by a bucket elevator to a cylindrical screen, from which it passes to the storage bins and thence by a belt conveyor to the concrete mixing machine delivering through 2-yd. steel buckets pushed on narrow-gauge cars to the cableways which transfer it to the required points on the dam. The concrete machinery is contained in a wooden tower and is operated through clutches by an 18x22-in. engine driven with compressed air at 110 lb. pressure. An additional boiler plant was eventually installed to operate the crushers independently.

Water for the steam plant and for the dam was at first provided by two large pumps installed on the river bank below the dam which deliver to an elevated wooden tank. Later, in order to provide an additional water supply at the north end of the dam, a Worthington pump was installed on a raft in the river and delivers through a 2-in. pipe 800 ft. long to a 3,000-gal. wooden stave reservoir tank at elevation 380 which provides an independent supply with a good head for the work most remote from the original water station. A blacksmith shop, machine shop, carpenter shop and saw mill, all well equipped with machine tools, were also provided near the power house and served for maintenance, repairs, and the construction of much of the plant used by the contractors. Buildings were also erected for offices, store houses, commissary, lodging and a number of small cottages for foremen and mechanics.

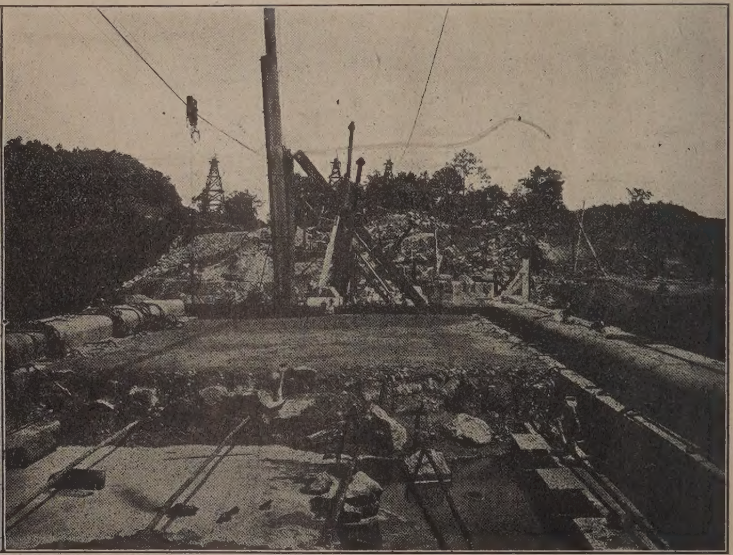
An area of over 40,000 sq. ft. was levelled on the south hill at an elevation of about 50 ft. below the crest of the dam, and in it were installed forms for casting about 200 large face blocks at once which were constructed at a maximum rate of 65 per day by a 10-man gang, using a rolling overhead concrete platform. This yard was equipped with five boom derricks which handled materials, forms and blocks and piled the latter in storage often to a height of 5 or 6 tiers.

These derricks interlocked and loaded the blocks on cars delivering directly to one of the main cableways which usually transported them out on the dam during the night, leaving it available during the day for delivering stone to the crushers. Normally two of the cables were in constant use in the day time delivering concrete to different parts of the dam, where it and the cast blocks were handled by stiff leg derricks with 60-ft. booms arranged clear of the working face in two rows, one on the upstream and one on the downstream side.

These derricks were at first seated on the ground and afterwards as the work progressed and the elevation of the top of the masonry rose above their effective clearance they were successively lifted up and seated on towers against the faces of the dam. All movements of the derricks were generally made at night when they were handled rapidly and easily by the cableways which transferred them bodily to their successive positions with minimum trouble and often without any interruption of the work. This system promoted the utmost rapidity of construction and although it involved a large amount of plant, has been found very satisfactory.

In the later part of the work this arrangement was somewhat modified by transferring seven of the derricks to the top of the wall. With this arrangement, the six 9-man gangs of masons and the four 3-man gangs of block layers laid 980 cu. yd. in one 10-hr. day. In this masonry the proportion of rock to the entire volume of the masonry varied from 12 to 22 per cent. The output of the quarries was closely regulated by the amount of stone required for the dam and averaged about 2,500 cu. yd. per week. About 580 cu. yd. of concrete was a maximum output for one 10-hr. day.

Block Yard, Concrete Tower and Machine Shop.


Roadway Foundation and Bars in Crest of Dam.

In order to facilitate the handling of materials from the cableways to the derricks on top of the dam, six 20x30-ft. landing platforms were built at equidistant points on the down-stream face of the dam. The decks were made of 6-in. ties carried on wooden towers with their vertical posts braced on all sides and secured at the feet to inclined timbers resting against the curved face of the masonry and abutting at the bottom on a longitudinal timber sill laid on the surface of the ground. The platforms were at first built at elevation 272 and afterwards as the masonry progressed were raised to elevation 289, 42 ft. below the crest.

The large face blocks of a maximum weight of about 6 tons each were cast in knock-down forms arranged in rows in the casting yard, and after they were at least 2 days old were stripped and later turned over and finally stored in tiers until required in the dam. The concrete was shoveled into them from an overhead rolling platform and as none were cast in cold weather, their manufacture was very much delayed by the late season this spring, so that only about 1,000 cu. yd. were manufactured during the month of May. The weight and dimensions of the blocks are so great that when the work was commenced considerable difficulty was encountered by the springing of the moulds and consequent bulging and convexity of the blocks. This was finally remedied by taking great care to tamp and solidify the ground under the moulds and by reinforcing the moulds themselves.

The best results were obtained by casting the blocks with the exposed face downward, and in some cases where two faces were exposed, one side of the mould was inclined slightly from the vertical to give a little pressure of wet concrete against that face. At first dog holes were cored in the blocks when they were cast, but as this was found unsatisfactory, the practice was later abandoned and the holes were cut by hand as soon as possible after the blocks were stripped. A maximum of about 7,000 cu. yd. of molded blocks were stored at once in the yard. The blocks and all other concrete were made with Giant cement and weighed 151 pounds per cubic foot.

All cement was sampled and sealed in bins at the mills and tested at the site. After its receipt at the dam it was held to await the results of 7-days' test before use and usually showed improvement.

The 32½x24½-ft. gate house on the up-stream face of the dam has monolithic concrete face walls cast in position with sliding shutters moved upward in the usual way as the work progressed and arranged to have their lower edges always overlap the finished concrete work and preserve the alignment of the upper part. The 3x6-ft. panels were made of 2-in. tongue and groove horizontal boards with vertical cleats 3 ft. apart and were held in place by ⅝-in bolts 18 in. long threaded at their inner ends to engage nuts and washers permanently bedded in the concrete 12 in. from the surface.

To facilitate the most expeditious construction of the masonry by avoiding the constant movement of derricks and the obstruction of the working surface of the dam, the original designs contemplated the support of a number of, derricks on permanent steel towers built into the concrete masonry. With this system it was intended to deliver stone and concrete by cars on a horizontal service platform alongside the dam. This involved the use of about 160 tons of steel in the towers at an estimated cost of $100 per ton, 1,600,000 ft. board measure of lumber at $40 per thousand and 5,000 lin. ft. of round piles. The use of this system was not obligatory on the contractor and the specifications gave him the option of executing the work in the manner outlined or of adopting any alternative plan which the engineers were convinced would give equal or more satisfactory results.

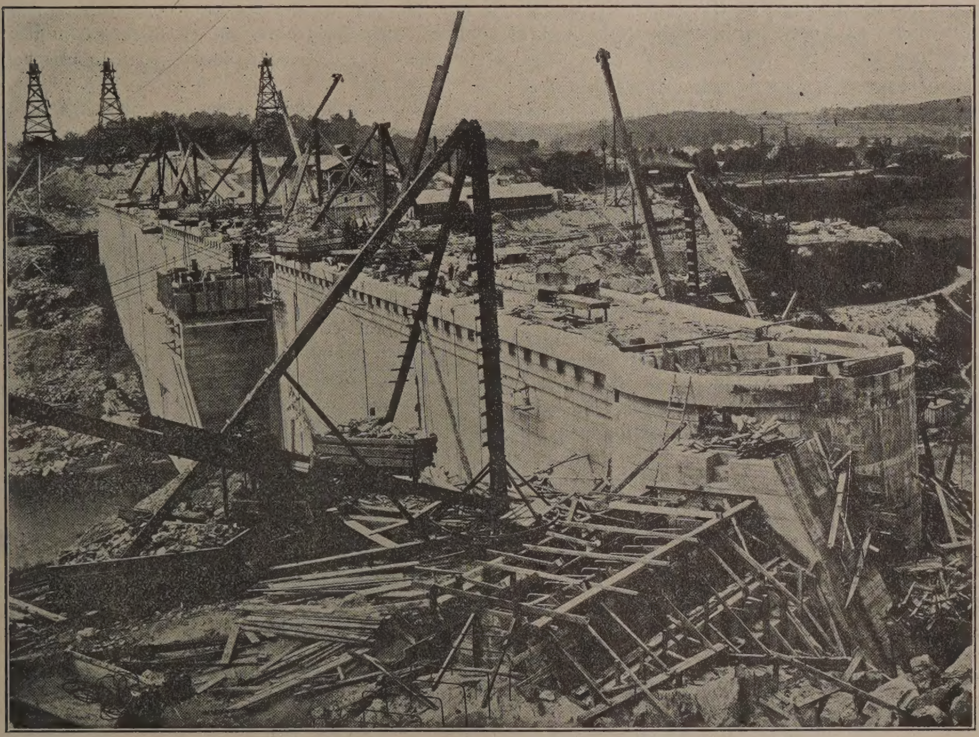
As the contractor was in a position to cover the work with an unusually large installaton of cableways he was allowed to substitute them for the derrick tower system, and it is considered that the results justified the substitution, and that this plan was the most desirable one both on account of the facilities it afforded for the very rapid movement of all other portions of the plant, such as derricks, platforms, etc., without dismantling them, and because, as the height of the structure increased and the width of the working surface diminished, the vertical movement of materials decreased correspondingly, thus facilitating the rapidity of operations. With the derrick system, on the contrary, the height to which materials were hoisted and the consequent time required to lay a given amount of masonry increased in direct proportion to the height of the structure.

A cofferdam was built around the upper end of the two 5-ft. steel flume pipes, which carried the flow of the Cross River through the dam during construction, and on July 24th the flow was cut off and during the following night the water level in the reservoir rose 18 in., and the water commenced to flow through the permanent waste pipe at the rate of about 7,000,000 gal. daily, an amount corresponding approximately to the minimum dry weather flow of the river. The flume pipes were immediately closed with rubble masonry very carefully filled in by gangs commencing at the middle and working both ways to the end. The rubble was packed as close as possible, the ends of the pipe were securely closed by heavy dish plates and rubber gas tips bolted on and afterwards all interstices in the masonry were filled by grout forced in under pressure through a full-length perforated pipe.

Besides the construction of the dam the work in progress involves the building of about 1½ miles of macadamized road, 1½ miles of grading, and 5½ miles of gravel road 28 ft. wide. There will be required about 20,000 cu. yd. of open cut at Cross River and 25,000 yd. of cut and 18,000 yd.

of fill at the reservoir and two 40-ft. concrete arch spans across the river and the spillway, involving respectively about 250 and 400 cu. yd. of concrete. The work throughout has been handled as a unit, different portions of it being accelerated or retarded and groups of men shifted from one service to another to maintain a uniform progress and secure the most rapid total advance. A maximum force of about 650 men has been employed and the contractors established a camp large enough to accommodate 600 of them, besides 3-room cattages, boarding hall and dormitory for 60 foremen and mechanics. The camps were supplied with electric lights and water and were carefully cleaned and disinfected twice a week.

Very few fatalities have occurred on the work and there has been no serious accident or epidemic. A regular physician has been retained to care for all cases of sickness and injury without charge to the patient and is paid for out of a fund provided by an assessment of 60 cents per month each on every person employed on the work from the superintendent down. Beds were provided in the New York and White Plains Hospitals as required.



View Looking Downstream, Showing Gatehouse and Bastions.

Mr. W. H. Sears is the chief engineer, and Mr. G. G. Honness is the acting division engineer. Mr. James Winston, of the contracting firm, and Mr. M. J. Look, chief engineer, are in direct charge of the work.

An Unusual Hot Blast Heating System has recently been installed in a hospital at Salinas, Cal., in which a furnace heater is used as the source of heat instead of steam coils. The hospital is a 37x90-ft. two-story brick building, and has accommodations for about 30 persons, for which a system with a capacity for delivering about 3,000 cu. ft. of air per min., or the equivalent of about 6,000 cu. ft. per capita per hour, was installed. As there is no steam plant installed, the fan, a 55-in. centrifugal blower, is driven by an electric motor and the air delivered is heated by a large Royal hot air furnace, located in an enlargement of the air casing. The hot blast is distributed by ducts in the basement ceiling with flues rising to each room.

British Power Plant Accidents in 1906.

The annual report for last year of Mr. Michael Longridge, chief engineer of the British Engine, Boiler & Electrical Insurance Co., of Manchester, England, gives interesting information concerning accidents to power plants. The only thing about most of these accidents that is not regrettable is the fact that the information they afford is turned to the use of builders and users of such equipment through these annual reports, which give warning of danger at the expense of somebody else.

The rate of breakdowns among insured steam engines was unusually high during 1906, amounting to 1 in 8.1 of the engines insured, although among oil and gas engines it was lower, 1 in 12.4. The reasons assigned for this difference are that gas engines have fewer parts than steam engines, these parts are generally much smaller than the parts of steam engines of the class insured, and gas engines cannot be habitually subjected to stresses much heavier than the parts were designed to bear. The percentages of the total number of failures of all kinds which were caused primarily by the giving way of various parts first were as follows: Valves and valve gear, 23.3; spur gearing, 12; air pump motions, 9.9; columns, entablatures, bedplates and pedestals, 8.6; air pump bucket and valves, 6.9; cylinders, valve chests and covers, 6.1; connecting rods, straps and bolts, 5.6; main shafts, 5.2, and other parts in smaller percentages. Twenty-eight per cent. of the breakdowns were due to accident or unascertained causes, 36 per cent. to old defects or deterioration by wear and tear, 22 per cent. to the negligence of owners or attendants, and 14 per cent. to weakness, bad design, workmanship or material. In the case of gas and oil engines, the failure is believed to have begun in the valves and valve gear in 28.7 per cent. of the cases; cylinders and cylinder ends 16.7 per cent., main shafts, 15.7; connecting rods and their bolts, 12; govenors and governor gear, 7.4; pistons, 6.5. The unusually high percentage of breakdowns in steam engines on account of wear and tear is attributed to the exceptional activity in the cotton trade, which encouraged spinners and manufacturers to increase their production and consequently their demands for power to the utmost. The increased strain upon the engines found out weak parts which, under rather easier conditions of working, might have remained serviceable. On the other hand the percentage of breakdowns ascribed to weakness, bad design, workmanship and materials was unusually low.

Some of the accidents are described at some length by Mr. Longridge. One of these, interesting as showing the value to power plant owners of the advice of the company's inspectors, occurred to an engine on which more than £300 insurance was refused. It was a horizontal tandem compound engine, with cylinders 19⅛ and 35 in. diameter, by 4 ft. 6 in. stroke, running at 68 revolutions per minute, with a boiler pressure of 120 lb. per square inch. The power, about 450 i. h. p., was transmitted by a rope drum, 24 ft. diameter, grooved for 24 ropes, 1½ in. diameter, and weighing about 21 tons. The peripheral speed at 68 revolutions per minute was, therefore, 5,060 ft. per minute. One morning, while the engineman was filling the crank pin lubricator, he became aware that the engine was gaining speed. As the stop valve was placed between the cylinders, and therefore in a direct line with the rope wheel, he ran to the boiler-house to close the junction valve, but before he could reach it the rope drum burst. All the segments and arms were torn off and broken, leaving the boss only upon the shaft. One of the pieces fell through the boiler-house roof and broke the steam main; other pieces smashed the air pump, condenser, and exhaust pipes, valve and governor gear, and destroyed the engine-house roof. Fortunately, the cylinders escaped. The mill was stopped one month. The accident would probably have been prevented, Mr. Longridge states, by the use of a "knock-off," the absence of which has been reported many times.

Another instructive accident happened to a pair of horizontal tandem tri-compound engines, with high-pressure cylinder, 22 in. diameter, intermediate 35 in. diameter, and two low-pressure, each 40 in. diameter, the high-pressure and one low-pressure piston being coupled to one crank, and the intermediate and the other low-pressure piston to the other crank. The stroke of the pistons was 6 ft., the speed 43 revolutions per minute, and the boiler pressure 160 lbs. per square inch. The power—about 960 i. h. p.—was transmitted by a spur flywheel and pinion, 18 ft. 9 in. and 6 ft. 5 in. diameter respectively. Soon after breakfast one morning a fire broke out in one of the spinning rooms which the engine drove. The operatives at once threw off the machinery and made for the exit, and the engine began to gain speed. The engineman ran to the "knock-off" gear, pulled the trip gear out of action, and began to close the stop valve. While thus engaged, he received an urgent order to start the fire pump, and left the engine-house with the engine slowing down and the stop valve nearly shut. As soon as he had gone, a mechanic rushed in, and, finding the engine still in motion, and no one present, threw the trip gear into action and opened the stop valve as quickly as he could, thinking, in his excitement, that he was closing it. The engines at once began to race, and before the valve could be shut down, had attained sufficient speed to break the cast-iron bell crank levers which drove one of the air pumps. Fortunately, no further damage was done. It is in emergencies like this, Mr. Longridge points out, that such an apparatus as an electric stop motion, which enables anyone to stop the engine by simply pressing a button in the engine-house or in any room in the mill, is useful.

On account of the few instances in which the complete history of broken shafts can be ascertained, the three following cases are important:

The first shaft accident happened to a McNaughted beam engine, with cylinders 20 and

26 in. diameter; strokes of pistons, 2 ft. and 4 ft.; revolutions, 50 per minute; boiler pressure, 75 lbs. per square inch. Power transmitted by spur wheel and pinion. Crank shaft, 23 years old, of wrought iron, with neck 6⅞ in. diameter and 9½ in. long. Bending stress, crank on centre, 7,075 lb. per square inch. Stress due to combination of bending and twisting, 7,920 lb. per square inch. Number of revolutions made by shaft, 193¼ millions. The shaft failed in the neck, the crack being partly longitudinal and then circumferential.

The second shaft accident happened to a horizontal tandem compound engine, with cylinders 17¼ in. and 30 in. diameter, by 3 ft. 6 in. stroke, running at 77 revolutions per minute, with a boiler pressure of 100 lb. per square inch. Power transmitted by spur wheel and pinion. Crank shaft, 19 years old, of wrought iron, with neck 10 in. diameter, by 16 in. long. Distance from centre of bearing to centre line of engine, 19⅜ in. Load on crank pin, about 30,000 lb. in recent years, probably somewhat less in early life. Bending stress with 30,000 lb. load, 6,280 lb. per square inch; combined bending and twisting, 7,400 lb. per square inch. Life of shaft, about 246 million revolutions. The fracture was diagonal for one-third of circumference of neck, and forked at each end.

The third shaft accident happened to a horizontal tandem compound engine, with cylinders 15 in. and 30⅛ in. diameter, by 5 ft. stroke, running at 41 revolutions per minute, with a boiler pressure of 110 lb. per square inch. The crank shaft was of wrought iron, with neck 9⅛ in. diameter, by 15⅛ in. long. The body of the shaft was 10 1-16 in. diameter, swelled to 11 in. to carry the spur flywheel by which the power was transmitted. The shaft broke at the end of the neck farthest from the crank at the junction of the neck to the body. The fracture was circumferential, and practically lay in a plane at right angles to the axis of the shaft, and had extended deeply into the neck all round before the final break. There was no fillet at the change of section where the crack occurred.

The engine was built in 1876 as a simple condensing engine, the low-pressure cylinder being the original cylinder, and worked as such with a boiler pressure of 50 lb. till 1890. The diameter of the cylinder was then reduced by the insertion of a liner to 26 in., and a new high-pressure cylinder placed behind it, converting it into a tandem compound engine. At the same time the boiler pressure was raised to 110 lb. per square inch. In July, 1905, more power was required, and to obtain this the liner was taken out of the condensing cylinder, which was bored out to 30⅛ in.

When the alteration was proposed, the Insurance Company strongly advised the replacement of the shaft which had worked for nearly 30 years, but as there was no outward or visible sign of decreptitude the advice was not accepted, and the old shaft was retained. Fourteen weeks later it broke, as described above. The stresses which it sustained are given with fair accuracy as follows:

1876 to 1890; 95½ million revolutions; from bending moments, between 7,600 and 8,450 lb. per square inch; from bending and twisting moments, between 6,800 and 7,200 lb. per square inch.

1890 to 1905; 103½ million revolutions; from bending moments, about 6,800 lb. per square inch; from bending and twisting moments, about 8,700 lb. per square inch.

July, 1905, to October, 1906; about two million revolutions; from bending moments, about 8,150 lb. per square inch; from bending and twisting moments, about 11,000 lb. per square inch. The total number of revolutions was about 202 millions.

Another class of accidents is due to the defective manipulation on condenser plants. A case of this sort was an accident to an inverted vertical two-crank compound engine, with cylinders 12 and 19 in. diameter, by 9 in. stroke, coupled to a continuous current dynamo, giving 700 amperes at 220 volts. Speed, 435 revolutions per minute. Boiler pressure, 160 lb. per square inch. The engine was connected to an independent jet condenser, with an air pump driven by a small electric motor, receiving current from the bus bars on the main switchboard. The set was used for lighting the mill previous to the starting of the main engine at 6.30 a. m. After that hour, the current required both for the lighting and for driving some motors was supplied from a 250-kw. machine driven by the main engine. In transferring the lighting from the smaller to the larger dynamo, the custom was to bring up the voltage of the latter to 220 volts, to switch it on to the bus bars, so as to run in parallel with the pilot dynamo, and then to switch off the latter and stop the pilot engine. During this operation the speed of the main engine had to be regulated by the opening of the stop valve, as the governor would not keep it steady while the load was light.

Under these conditions it is evident that if the steam supplied to the main engine at the moment of switching in the larger dynamo were just sufficient to keep the voltage steady at 220 volts while the dynamo did no work, it would be insufficient to keep the engine up to speed and the voltage of the dynamo up to 220 volts when the load was transferred from the pilot set, or when any of the motors in the mill were started. The maintenance of the voltage would therefore depend upon the manipulation of the stop valve of the main engine by the engineer. If it were not promptly opened, the voltage would fall and the current taken by the motors would increase. On the other hand, if the stop valve of the main engine were opened too quickly or the steam shut off the pilot engine too soon, the pilot dynamo might run as a motor receiving current from the main switchboard. Indeed, the conditions were such as to demand considerable experience and watchfulness on the part of the operator to accomplish the change over without a hitch.

It is not surprising, therefore, that accidents occurred. The first was typical of many others, resulting from the improper manipulation of independent jet-condensing plants. It occurred at 6.30 a. m. one morning on stopping the pilot engine when the main engine had taken the lighting load, and was caused by the attendant switching the current off the air-pump motor, thus stopping the air pump before the pilot engine had come to rest, and before the vacuum in the cylinders was destroyed. The result was that the injection water, instead of being carried away by the air pump, filled up the condenser and exhaust pipe and overflowed into the cylinders, causing the breakage of both cylinder covers.

New covers were obtained during the day, and the engine was started again early the following morning, when another accident occurred, this time through some mistake or want of skill in changing the lighting load over from the pilot to the main dynamo. Exactly what happened could not be ascertained, but the effect of the mistake was that while making the change the voltage suddenly dropped and the current increased sufficiently to throw out the circuit breaker between the main dynamos and the bus bars, and cut off the current before the pilot engine had come to rest. This stopped the motor which drove the air pump for the condenser connected to the pilot engine, and the water again got into the cylinders. The damage on this occasion was not limited to two broken covers. Both cylinders were broken, also the high-pressure piston rod, piston-rod crosshead and guide, and the connecting rod was bent.

Many independent jet-condensing plants are dangerous unless the following rules are observed: 1, Shut the injection cock before stopping the engine. 2, Stop the engine before stopping the air pump. A vacuum breaker arranged to come into action automatically when the water rises above a certain level in the condenser is also a safeguard, so long as it remains in working order, but its adoption should be no excuse for breaking the rules given above.

An accident to an air pump that deserves mention happened to the equipment of a pair of horizontal cross-compound engines, 21 years old, with cylinders 38 and 66 in. diameter by 6 ft. stroke, running at 52 revolutions per minute, with a boiler pressure of 100 lb. per square inch. The power was transmitted by a drum grooved for 40 ropes 1¾ in. diameter, carried on the crank shaft between the engines. The air-pumps, two in number, each 37 in. diameter by 20 in. stroke, were driven by a bell-crank lever from the tail rod of the low-pressure engine.

On looking round the engine one morning, the engineman noticed a vertical crack in one of the air-pump barrels. On closer examination he found several others, which were extending. He at once stopped the engine, and drew the air-pump bucket. He then found the rings very thin, one of them broken in pieces, and the part of the coil spring jammed between the bucket and the barrel. The bucket was said to have been examined six months before the breakdown, but it was quite clear from the worn condition of the rings that no proper examination had been made. The rings were said to be 21 years old. Fortunately the practice of fitting rings into the buckets of vertical pumps has been almost universally abandoned. Besides being a source of danger, they are quite useless, in Mr. Longridge's opinion.

The air pumps usually put in are so large that considerable water leakage may take place past the buckets without materially affecting the vacuum. Not long ago one of the Insurance Company's inspectors found an air-pump bucket, without packing rings, ¾ in. less in diameter than the barrel, yet the vacuum varied from 10 to 12 lb., according to the load on the engine.

Turning to gas-engine accidents it is interesting to observe that the breakages of crank shafts in 1906 were fewer than in 1905, although the number of engines insured was greater. The decrease is no doubt due to the larger diameters which many makers of gas engines have adopted during the last two or three years. Shafts which might have been strong enough five years ago are insufficient for the higher compressions and heavier flywheels now in use, while shafts which were too weak for the old conditions are still more inadequate to-day; calculations of the stresses upon the shafts of gas engines are so difficult and uncertain as to be practically impossible, and makers have to rely to a very large extent on experience, which can only be gained slowly and at considerable expense.

The general practice seems to be to make the shafts and particularly the crank pins, of small engines relatively stronger than those of large. Calling C the diameter of the cylinder, D and d the diameters of the crank pin and shaft journals respectively, l the distance between the bearings on each side of the crank, and r the length of the crank arm, all in inches, the following values of $C^2 (l + d) \div D^3$ and $C^2 r \div d^3$ represent roughly the best modern practice. For engines with cylinders below about 12 in. diameter the value of $C^2 (l + d) \div D^3$ varies from 10 to 11, and rises to about 15 for engines with cylinders 20 in. diameter. For small engines, also, the value of $C^2 r \div d^3$ is usually 10 to 11, but does not often rise much above 13 for large.

The shafts of some makers give larger constants, and are consequently weaker than those from which the figures given were derived, but in such cases the tendency is to increase diameters. Nevertheless, weak shafts are still being made, and in the keen competition for business the makers of these shafts gain an unfair advantage, for the buyer of a gas engine, particularly a small one, has seldom the fainest idea whether the shaft supplied to him is strong or weak. Mr. Longridge is inclined to think that $C^2\ (l + d) \div D^3$ should have a value of about 12 for engines with two bearings and overhanging flywheels, and about 14 for engines with three bearings, and $C^2r \div d^3$ a value of about 10. In any case, large fillets at the junctions of the journals with the crank webs are most important.

Of the shafts that broke in 1906, 77 per cent. had two bearings, 23 per cent. had three or more bearings. Of the shafts with two bearings, 53 per cent. had one flywheel, 47 per cent. had two flywheels. Of the shafts with two flywheels, one broke in one of the crank arms, and one in the body close to the skew wheel for drivng the side shaft. The rest broke in one of the necks, usually the neck at the end which carried the driving pulley.

Of the shafts with one flywheel, two broke in the crank pin, the rest in the neck between the crank and the flywheel. The shafts with three bearings all broke in the neck between the crank and the flywheel.

The breakage of the shaft of the two-flywheel engine close to the skew wheel was unusual. The engine was six years old. It had a cylinder 6¼ in. diameter by 12 in. stroke, and ran at 160 revolutions per minute with town gas. The shaft was of steel 2¼ in. diameter, with two bearings, each 6 in. long. The skew wheel was fixed close to the end of the left-hand bearing, and just beyond it was one of the flywheels. The other flywheel and driving pulley were at the other end of the shaft. The left-hand end of the shaft, with its flywheel, dropped off and careered across the engine-room, and the skew gear was broken. The fracture occurred close to the edge of the skew wheel and between it and the flywheels. It was at right angles to the axis of the shaft, and partly old. Apparently it had started with a skin crack produced by a scriber or by pressure of the sharp edge of the skew wheel, and had then extended across the shaft.

Special attention is called in the report to the fact that the connecting rod bolts give way more often than might be expected, and that flywheels are found loose so often it is probable the keys are not deep enough or are not fitted with sufficient tightness against the driving surfaces of the keyways in contradistinction to the beds. It is also doubtful whether many of the flywheels fit their shafts well enough to be held securely with one sunk key.

One of the most interesting gas engine accidents recorded in the report related to a horizontal gas engine 10 years old, with cylinder 16 in. diameter by 20 in. stroke, running at 160 revolutions per minute with lighting gas from a town main. In November, 1905, the cylinder end fractured, and was replaced. In November, 1906, the new end cracked. The cause was overheating, due to the accumulation of deposit in the water jacket. The owners had been repeatedly advised to keep the water spaces clear, and professed that they were careful to do so. In fact, the Insurance Company's inspector was informed that the jackets had been cleaned five weeks before the crack was noticed, yet when the end was taken off and broken the whole of the heated surface was found coated, and the water spaces round the exhaust-valve chamber completely filled with lime. Pieces of deposit ⅞ in. thick were taken from them.

The case clearly proves the necessity for providing mud holes in the jackets of the cylinders of gas and oil engines, Mr. Longridge states. The company has urged this necessity for many years, but has been met by the argument that, as the water never attained, or ought never to attain, a temperature high enough to cause deposition of lime, mud holes were not required. There is no doubt, however, that hard waters do deposit lime and dirty waters mud, and that provision should be made for removing both. Happily the necessity is now being recognized, at least in the case of large engines. Small ones, however, are still turned out in great numbers without any convenient means of cleaning out the jackets of the cylinders.

In the case of electrical machinery, the breakdowns increased in a somewhat lower ratio during 1906, both in number and in cost, than the number of dynamos and motors insured. In the case of motor-starting switches, however, breakdowns have increased far more rapidly than the number of instruments insured and the cost of repairs in a still higher ratio. The number of breakdowns during 1906 among dynamos was 1 in 16, and among motors 1 in 8.2. Accidents due originally to faults in armatures and rotors made up 44 per cent. of all; commutators and brush gear, 28 per cent.; magnet coils and stators, 14 per cent.; the remaining accidents were too varied to be classified. Of all the breakdowns 22 per cent. were accidental, 11 per cent. were due to age and neglect; 23 per cent. were due to age and deterioration, 9 per cent. were due to bad workmanship and design, and 7 per cent. to overloading.

The inspection of steam boilers and other containers exposed to internal pressure is, in some respects, the most difficult branch of the company's business. While, by the passing of the Factory Act of 1901, Parliament practically, although not explicitly, entrusted the duty of inspection to the boiler insurance companies, it gave them no compulsory powers. It threw the duty of inspection on experienced and responsible bodies, and at the same time compelled those bodies to consult the convenience and necessities of the boiler owners. Most of the demands for increases of pressure by boiler owners and of requests for reduction of pressure on the part of the inspecting companies involve differences of opinion which can only be reconciled by tact and compromise; while the companies have to consider the conveniences and financial necessities of boiler owners on the one hand, they have also to remember that, in the event of anything going wrong, their decisions will be reviewed by a tribunal by training and habit little likely to give purely commercial considerations the importance they have in the eyes of the manufacturer or in the eyes of the insurance companies, which have a more intimate knowledge of his difficulties.

The statutory inspection of boilers under the Factory Act is limited to one thorough inspection every fourteen months. During 1906, 92 per cent. of the boilers coming within the scope of the Act were thoroughly inspected, and over 50,000 inspections were made which were not required by the Act. The serious defects reported during the year were 123 cases of corrosion and grooving, 37 cases of fractures, and five cases where the mountings were out of order or inoperative. Before the end of the year 87 per cent. had been attended to.

The Average Performance of Steam Shovels in the iron ore deposits in the Mesabe Range, Minnesota, is about 900 cu. yd. per day of 10 hr. Three shovels together have made a maximum record of 190,000 cu. yd. in a month, a rate per shovel of 1,218 cu. yd. in 10 hr.

The McNulty Building, New York.

The 10-story and basement reinforced concrete McNulty Building, which occupies a 50x95-ft. 9-in. site on the north side of 52d St., between 10th and 11th Aves., New York City, is one of the first small-column reinforced concrete buildings erected in the Borough of Manhattan. The columns, which are of the hooped variety, were designed in accordance with the formula, $P = 1{,}600r^2 + (160{,}000\ Ah \div p) \times r + 6{,}000\ As$, recently developed by the Bureau of Buildings of the Borough of Manhattan for hooped columns. In this formula $P =$ the total working load, $r =$ the radius of the helix, $As =$ the total area of the vertical steel, $Ah =$ the sectional area of the hooping wire, and $p =$ the pitch of the helix. The columns, girders, floor-beams, floors, roof and stairs are of concrete and the walls are of brick and stone. On the sides and rear of the building the panels formed by the wall columns and girders are filled with 12 and 16-in. brick curtain walls above and below the sixth floor, respectively, the exposed outer surfaces of the girders and columns being flush with the surfaces of the curtain walls. The two lower stories of the facade are ornamented with cut limestone and the two top stories with cast cement stone as shown in the accompanying illustration. The intermediate stories of the facade are finished with two shades of red pressed brick and stone window sills.

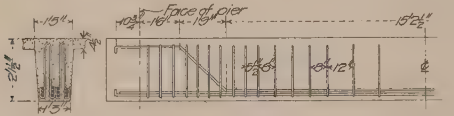
In plan the various floors are alike, being divided into two longitudinal and four transverse bays by a single line of interior columns placed on the longitudinal center line of the building on about 22-ft. centers. Except in the top story these interior columns are cylindrical in form, and in the basement and in all other stories except the ninth and tenth, they are 27 in. in diameter. In the ninth story the diameter is reduced to 21 in., and in the top story the columns are 12 in. square. Below the fifth floor the reinforcement in each of these columns consist of 2-in. round vertical rods, ranging in number from seven in the fifth story to thirty in the basement, surrounded throughout each story by a 24-in. helix of ½-in. wire with a pitch of 1½ in. Between the sixth and tenth floors the vertical rods are omitted and the diameter of the helix is gradually decreased while the pitch is increased. In the tenth story, four ¾-in. rods, one in each corner of the 12-in. square columns are used.

The side wall columns are in general 30x26 in., and carry loads ranging from 48,000 lbs. in the tenth story to 719,750 lbs. in the basement. Below the seventh floor the reinforcement in these columns consist of 2-in. round vertical rods, ranging from three in the sixth story to twenty-four in the basement, spirally wound with 5/16-in. steel wire forming a helix 23 in. in outside diameter with a 2½-in. pitch. Above the seventh floor the reinforcement is four ¾-in. round rods laced with ties of 5/16-in. wire on 18-in. centers. The columns, both wall and interior, rest on cast-iron shoes bedded on solid rock about 2½ ft. below the basement floor.

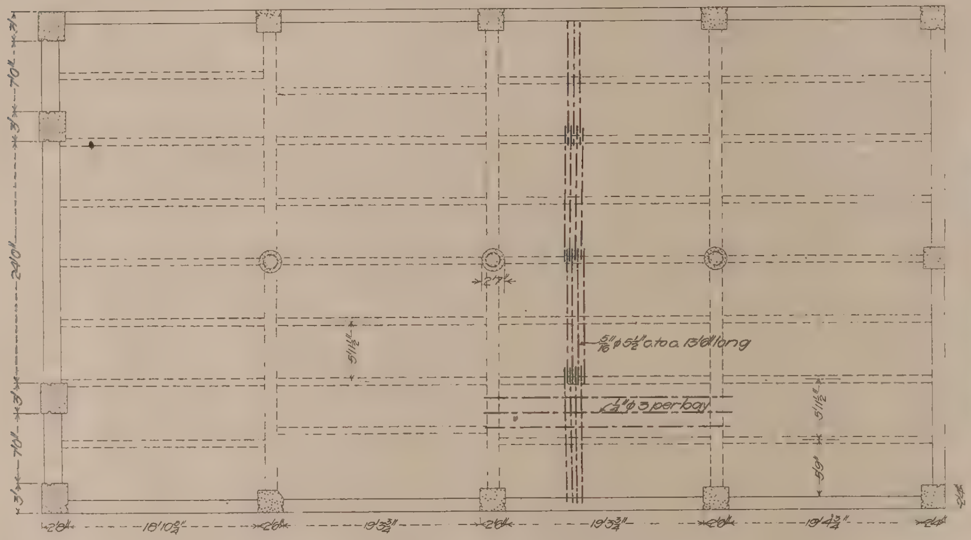
The main floor girders extend transversely across the building with a clear span of 21 ft. 8½ in. and are 21 in. deep, not including the 5-in. floor slabs. These girders are 15 in. thick at the bottom and 17 in. at the under surface of the floor slabs. Each is reinforced with twelve 1⅛-in. round rods and a large number of 5/16-in. wire stirrups arranged as shown in an accompanying sketch. The method of forming and placing the reinforcement in the columns and girders will be referred to later. The floor beams are placed in general 5 ft. 11½ in. on centers, the floor panels thus formed being about 5⅓x20½ ft. These beams are 15 in. deep, not including the 5-in. floor slabs, and 8 and 10 in. thick at the bottom and the under surface of the floor slab, respectively. Each is reinforced with two 1-in. round rods and two 1 1/16-in. round rods and with 5/16-in. stirrups disposed in the same general manner as those in the larger girders. The floor panels are reinforced with 5/16-in. round transverse rods on 5½-in. centers. These rods are cut 13½ ft. long and extend through two panels liberally lapping the succeeding rods at every other floor beam as shown in the floor plan. The side-wall girders have in general a clear span of 19 ft. 3¾ in. and are 2 ft. 2 in. deep including the floor slab and 12 in. and 16 in. wide above and below the sixth story, respectively. The reinforcement in the heavier of these girders consists of four ¾-in. round rods with 5/16-in. stirrups.

The brick work of the facade is anchored to the concrete by suitable anchor bolts and the weight over the windows is carried by cast-iron lintels.

The stairs on both sides of the building are of reinforced concrete with Mason's safety treads.



Floor Girder.



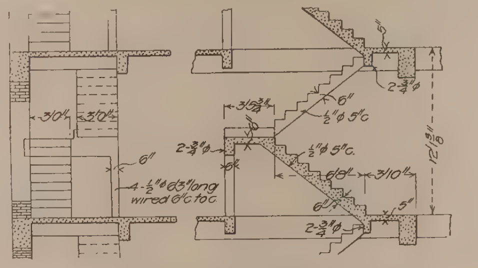
Floor Plan of the McNulty Building.

The stair slabs have a minimum thickness of 6 in., and in general are reinforced with ½-in. round longitudinal rods on 5-in. centers. Sections of the west stairs on which the reinforcement is indicated are shown.

The reinforcement for all beams and girders was fabricated into units in the shops of the contractor and shipped to the work ready to be put in place, and the helices for the columns were wound and attached to some of the vertical rods at the shop to preserve the pitch. The vertical rods in each column project 6 in. above the surface of the floor slab above, where they enter 12-in. gas-pipe sleeves into which the ends of the vertical rods in the next column are placed. To insure proper spacing the rods placed on the work were slipped through a wooden disc template with holes bored near its circumference at points immediately above the gas-pipe sleeves on the floor below. The reinforcement for each beam and girder was built as a truss, the stirrups being hot shrunk on the longitudinal rods in their proper positions. In some of the heavier girders two such trusses were made for each girder and placed side by side in the form. Each girder and column unit was shipped to the work bearing a tag numbered to correspond with a number on the plan showing the proper position of the reinforcement. This method of preparing and placing steel reinforcement, which is known as the Unit System, it is said, not only assures the accurate placing of the steel but also effects an economy of labor.

The concrete is a 1:2:4 mixture of Giant Portland cement sand and ¾-in. trap rock. It was prepared in a Ransome mixer and was elevated with a Ransome self-dumping hoist, wheel-barrows being used to distribute it on each floor. The placing of concrete was begun about the middle of August, 1906, and the building was completed December 20.

The structural designs were prepared and the reinforced concrete work executed by Messrs. Tucker & Vinton, New York City; Mr. R. L. Bertin, chief engineer; Mr. P. H. Trout, superintendent of construction. The architectural plans were made by Mr. W. C. Lewis, of New York. Mr. Thomas D. Connors was the contractor for the brick work.



Sections of Stairs.

An Interesting Business Organization.

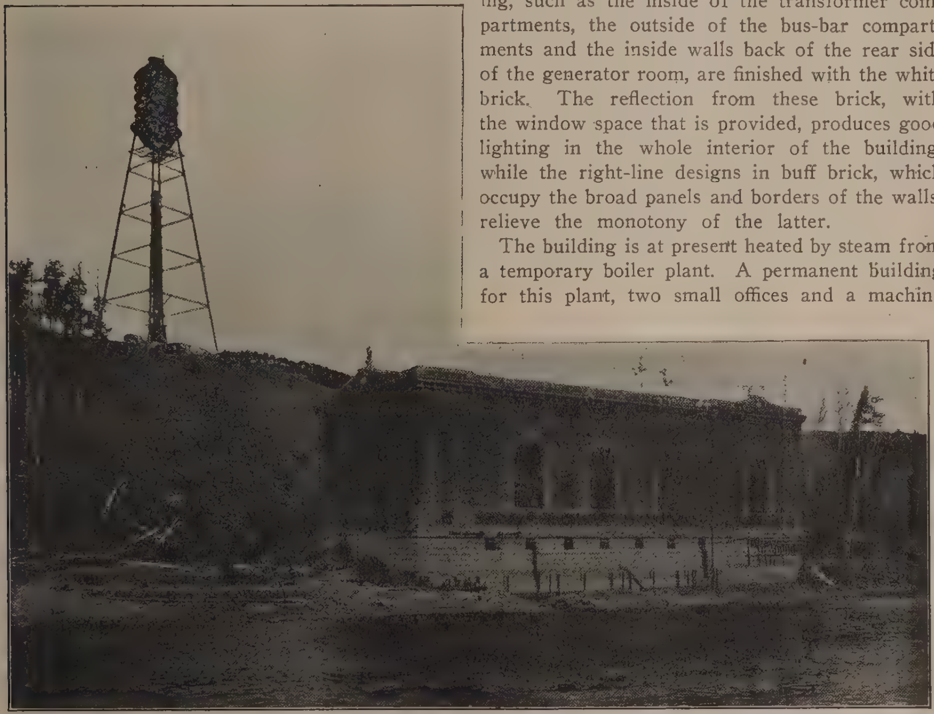
The business organization of the Stone & Webster Engineering Corporation of Boston is an interesting example of the perfection it is possible to attain in a large staff when care is taken to profit by past experience. When the firm of Stone & Webster began work on an extensive scale, construction was handled from its Boston office almost entirely. The more important details were designed there and the plans then turned over to a competent man who was sent to the site and allowed to finish up the work as he saw fit, funds being sent to him as he needed them. The work was done well under this method, but the headquarters office was generally in the dark concerning its progress and what it was costing. It was very soon discovered that there was a marked difference between a good constructor and a good engineer and that neither of them had any particular faculty of keeping the main office promptly posted concerning what they were doing. Even when reports were sent to headquarters, they were handled by different individuals and it was discovered that the data accumulated in this way were of little value for future work. About four years ago the Columbia Improvement Co. was organized to carry on the construction work the Stone & Webster Co. had in hand, but this plan, although a step in advance, proved to be not wholly satisfactory. Accordingly it was determined to combine the improvement company, the engineering department and the purchasing department, all of which are necessary factors in construction work, into a single organization, the Stone & Webster Engineering Corporation. The president of this company has three departments reporting to him, one under the vice-president and treasurer, the other under the engineering manager, and the third under the construction manager. The vice-president and treasurer looks out for the auditing, purchasing and office management at headquarters and the thirteen district offices. The engineering manager has charge of the engineering and architectural work and the drafting office. The construction manager has charge of thirteen district offices, and one of them, that in Texas, has three subsidiary offices. This organization keeps specially trained men in all the branches of engineering and construction work available for any of the Stone & Webster companies, and for general work.

The McNulty Building.

The Geological Conditions in the National Forests are to be investigated by the U. S. Geological Survey, the geologists being instructed to assist claimants to mineral lands in these reserves who are acting in good faith. The Government encourages mining in the forest reserves but many fraudulent entries have been found covering non-mineral lands and deposits which can never be profitably mined. The investigation will not only be of value to the Forest Service and to the miners, but will prevent such fraudulent practices.

The Hydro-Electric Development of the Great Northern Power Co.—Part II.

Station Building.—The building to house the ultimate installation of 80,000 h.-p. in generating equipment will be 77x313 ft. in plan, 90 ft. high, and of thoroughly fireproof construction throughout. A section of this building 181 ft. long has been completed, and is arranged to provide for the addition of the remainder. The design of the building is particularly well-chosen and was developed along pleasing artistic lines capable of practical application. The substructure of the building has a total height of 38 ft. and is of monolithic concrete built on a brown sandstone ledge which underlies the site. The superstructure has a steel frame enclosed in brick masonry trimmed with concrete blocks. The roof is carried by steel trusses which are a part of the building frame. The roof consists of book tile covered with four-ply roofing felt laid in asphalt and finished with tar and gravel.



Power Station during Construction, Showing Standpipe in the Rear.

The treatment of the exterior of the building is comparatively simple but produces a very satisfactory appearance. The outside walls of the substructure were molded to relieve the dead, flat surface of the concrete and the latter was carefully spaded in the forms to produce a homogeneous finish. The outside of the superstructure walls are finished with a mild red pressed brick. The concrete block trimmings, including the door and window lintels, the water tables, the stones of the corner columns and so forth, were cast in molds and were placed after they had hardened. The results secured by this combination of the brick and concrete blocks are all that could be desired.

The arrangement and finish of the interior of the building also evidence what can be done in proportioning and treating a structure of this type in order that the rough appearance so general in such structures may be relieved without diverging from practical limits. A basement, 18 ft. in height, extends under the entire building and forms the upper part of the monolithic substructure. The penstocks, water-wheels, auxiliary pumps and most other crude appearing equipment are in this basement. The latter is well lighted by windows on all four sides of the building, however, and its concrete walls were finished smooth as they were built. Above the basement, the building is divided into two equal parts by a longitudinal wall. A generator room, 38 ft. wide, occupies the river side; back of the wall and along the generator room are compartments for transformers, in the rear of which are compartments for the high-tension bus-bars, and the high-tension switching connections, and on a reinforced concrete floor over these various compartments are the main switches. The main floor of the building has a heavy reinforced concrete floor carried by the side walls of the substructure and by reinforced concrete columns. The inside walls of the generator room have a 7.5-ft. wainscoting of white enamel brick, above which they are finished with white and buff brick laid to right-line designs in the panels between the piers enclosing the columns of the steel frame and around the edges of the walls. Common building brick was obtained in both colors, so the designs were followed without added expense. All other interior surfaces of the building, such as the inside of the transformer compartments, the outside of the bus-bar compartments and the inside walls back of the rear side of the generator room, are finished with the white brick. The reflection from these brick, with the window space that is provided, produces good lighting in the whole interior of the building, while the right-line designs in buff brick, which occupy the broad panels and borders of the walls, relieve the monotony of the latter.

The building is at present heated by steam from a temporary boiler plant. A permanent building for this plant, two small offices and a machine shop, which would be distinct from the station building, has been contemplated, but it is now expected that space will be available for these purposes in the future extension of the main building.

The portion of the main building that is completed is designed to accommodate four 10,000 h.p. water-wheel-generator units, and exciters for eight units of that capacity. Three of these main units are being installed, and the fourth will be added as soon as it is required. These units are spaced 32 ft. apart on centers and are in a single row, with space for the exciters between the end of this row and the four additional units which are to be installed later in the future section of the building.

The initial hydraulic appartus consists of three turbine water-wheels, each having a maximum capacity of 13,000 h.p. under the available head of 378 ft. These wheels were built by the Allis-Chalmers Co., of Milwaukee, after general designs of the Escher-Wyss Co., of Switzerland. They are a modified form of the vertical-shaft Francis pressure type wheel, and are designed to operate at 375 r.p.m. Each of the wheels is connected by a penstock laid on the floor of the basement, with one of the 7-ft. pipe lines. The water is discharged from each wheel into a steel draft tube that passes through the basement floor and the front wall of the substructure to the river.

The penstocks are reduced in diameter gradually from 84 in. at their junction with the pipe lines to 66 in. just back of the wheels. At this 66-in. section a hydraulically-operated gate valve is placed in each penstock. These valves are set on edge on the concrete floor of the basement. They are believed to be the largest ever built for such high pressure, weighing 31 tons each and occupying a floor space 28 ft. in length. The water can be cut off from the wheels by these valves when repairs are required on the latter and also in case a leakage occurs through variable orifice gates in the wheels when the units are not in service.

Two 18-in. by-pass relief valves are placed on each penstock between the 66-in. gate valve and the water wheel which the penstock serves. These relief valves are built in a general way according to Escher-Wyss design. They are arranged so they can be operated automatically by a governor on the water wheel, or they can be set to open when the pressure in the penstock rises above a predetermined amount. It is intended at first to connect one valve on each unit so it will be operated by the governing mechanism of the water wheel and to set the other valve of each pair so it will open before the standpipe is overflowed. Each valve is fitted with a dash pot having a time-element release that closes the valve gradually and automatically after the pressure is relieved, in order to reduce the waste of water. As these relief valves are operated in multiple through the cross receiver at the standpipe, if one of them fails to work the remaining five will still be in service to meet the necessity for a relief of pressure. When the four additional main units are placed this multiple operation of the relief valves will be further improved.

The penstock of each water wheel terminates in a large tapering case, the cross-section of which is generally circular, the case being built on a spiral so as to surround the runner of the wheel. This case, generally termed the scroll case, is a steel casting made in two parts, having a combined weight of over 83,000 lb. Water is admitted to the runner from every point on the inner side of the scroll case, passing through an annular casting containing deflector blades and through movable guide vanes, or gates in a second case inside this annular casting. The scroll case, the annular casting and the guide case are all concentric with the shaft of the wheel. The movable gates, which are similar in general arrangement to register gates, resemble in shape to the head of an axe, thick at the middle, and each turn on a vertical pivot placed in the gate the same as the handle is placed in the axe. The gates are set in a circle concentric with the shaft of the runner, their arrangement being such that they overlap and can be turned to close the opening between them.

The amount of water supplied to the runner is controlled by the position of these gates, which position is determined in the following manner by a fly-ball governor driven by the water wheel: The pivots on which the gates are set extend to the top of the guide, or gate case, where they are each connected by a horizontal link with a bolt in a shifting ring, which fits around that case. This ring is arranged to revolve on an axis concentric with the shaft of the runner, but is required to move only a very slight amount in order to close or open the register gates. Two heavy links attached at diametrically opposite points on the shifting ring are each connected through a positive motion to the piston rod of one of two pairs of operating cylinders which are a part of the governing mechanism of the unit.

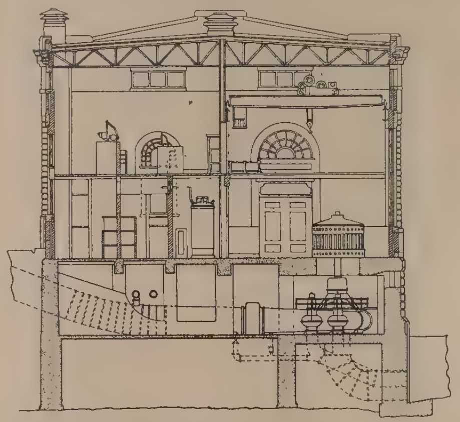
These two pairs of operating cylinders are placed horizontally, one pair on each side of a yoke over the wheel. The operation of each pair of cylinders is the same, the two cylinders of each pair being in tandem. Each cylinder contains a piston and the two pistons of the pair are connected to one piston rod. One cylinder of each pair is connected with the penstock, and the other with a high-pressure oiling system. The connection with the latter is through a pipe fitted with a variable orifice valve which is controlled by a fly-ball governor on the floor of the generator room, this governor being geared to the shaft of the runner of the water wheel. The pressure maintained on the oiling system being much higher than that in the penstocks, when the valve in the connection to that system is opened to admit oil to one cylinder of each pair, the pistons in the oil cylinders are pushed ahead against the lower pressure of the water on the pistons in the other two cylinders. The two pistons of each pair of cylinders are thus moved, the motion being transferred to the shifting ring by a link attached to the rod connecting the pistons, and through the links on that ring connecting with the pivot of the register gates the position of the latter is altered. A reverse motion is obtained by draining oil from the two oil cylinders, which reverse is also accomplished automatically by the governor. Each piston rod also carries a cross-head so it may be connected to one of the two relief valves of the unit by a long lever arm.

The runner of each water wheel is 62 in. in diameter and is mounted on the lower end of a vertical 15 in. shaft. The water passes horizontally into the wheel and then down through the draft tube. Such water as may splash over the top of the wheel will be drawn out of the case in which the latter is enclosed, by two 6-in. pipes leading down through the basement floor to a connection with the draft tube.

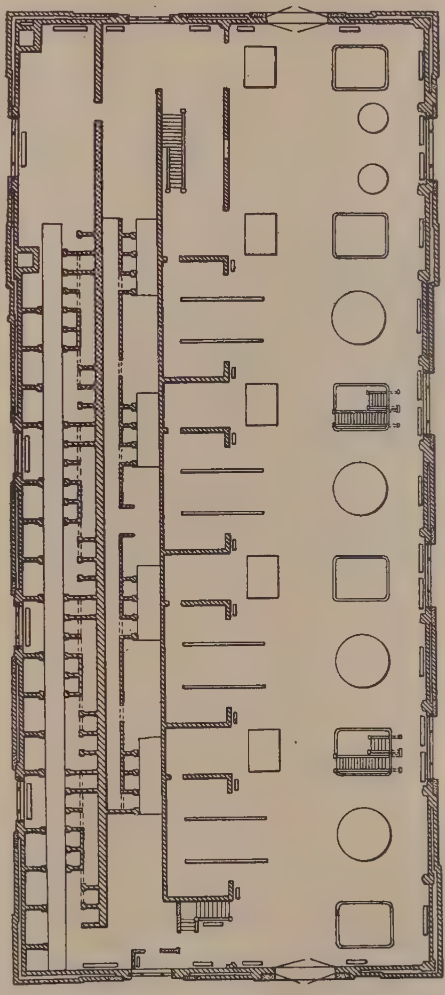
The generator of each unit is a 7,500-kw. 3-phase, 25-cycle, 6,600-volt vertical revolving-field machine built by the General Electric Co. The revolving field of each generator is mounted on an extension of the vertical shaft of the water wheel. The total weight of the revolving element of the unit is carried between the water wheel and the generator by a thrust bearing on the shaft. Two guide bearings are also provided to preserve the alignment of the revolving parts.

The thrust bearings each consist of a heavy ring attached to the shaft of the unit and resting on a second ring supported by a yoke on the wheel casing. The contact surfaces between these two rings are grooved and the weight of the revolving element of the unit is supported on oil forced between the two rings, which are enclosed in a tight case.

A complete system of pipes and pumps supply oil to the step bearings, each unit having an individual oil pump. These pumps are of the mesh-gear type and are specially designed for this service. They are two-stage machines, each stage being arranged to raise the pressure of the oil 200 lb. per square inch, so that the oil can be delivered at 400 lb. per square inch, if desired. Each stage consists of two closely-meshed gears operating to a snug fit in a tight gear case. The oil is squeezed through between the teeth of the gears as they mesh together with sufficient force to apply the pressure. The corresponding gears of each stage are on the same shaft, and the two shafts are geared to a third shaft. A Morris roller-bearing chain which passes over a sprocket on this main shaft and over a sprocket on a jack shaft geared to the vertical shaft of the main unit drives the pump. The latter takes suction from a central supply-tank under the basement floor and delivers into a small, closed, vertical receiver placed over it. One pipe leads from this receiver to the step bearing; a second pipe supplies oil to the cylinders of the operating mechanism which controls the position of the register gates of the water wheel. The drip from the bearing and the discharge from the cylinder are conveyed to a tank fitted with cooling coils through which water from the penstock is constantly circulated, the overflow from this tank being conveyed to the central supply tank by gravity.



Sectional Elevation of Power House.



Plan of Power House.

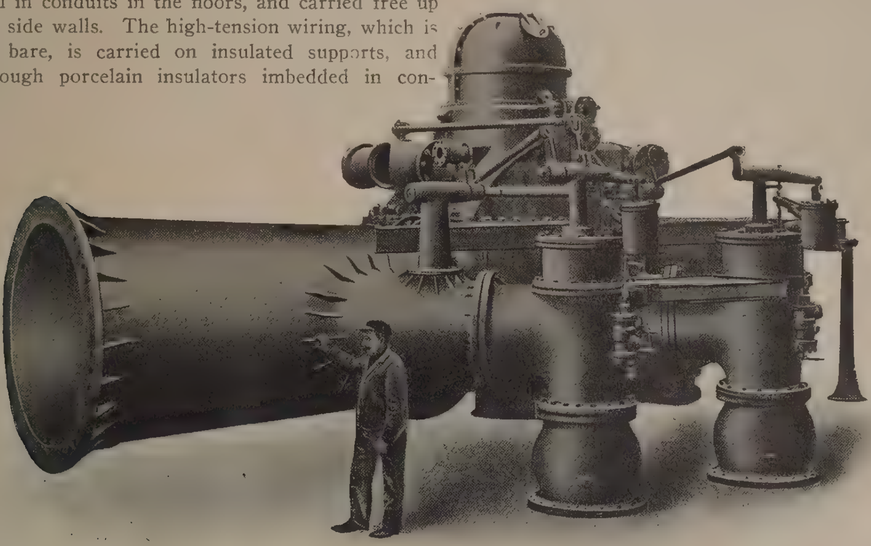
The oil supply system for each unit is also connected to a general system that is furnished with pressure by two pumps of the same size and type as those for the different units. These pumps are used while the units are being started and simply float on the oiling system as a relay. Each of them is operated by a bevel-gear drive from an impulse water wheel supplied with water through a connection with the penstocks. These reserve pumps draw from the central tank under the basement floor.

Exciters. Excitation current for the main generators is furnished by two 250-kw. 8-pole 125-volt direct-current generators each direct-connected to a vertical 500-h.p. impulse water wheel. Each of the generators has sufficient capacity to supply excitation current to all of the eight main units which the station will eventually contain. The water wheels are supplied with water from the penstocks, through a ring system of 16-in. pipes. Each leg of the ring is connected with each penstock and is fitted with valves arranged so either wheel can be supplied from any penstock. The amount of water furnished to either wheel is automatically regulated by a valve operated by a governor, but which can also be controlled by hand. The water is discharged from these wheels into the river through a pipe in the front wall of the building.

Transformers. Current from each main generator is delivered through auxiliary bus bars to a single 7,500-kw. three-phase transformer. The transformers are each placed in a separate fireproof compartment immediately in the rear of the generator room and at the level of the floor of the latter. They are the largest transformers of this type ever built, and on account of their size permitted several special features of design. Each transformer is 14 ft. 10 in. high, 14 ft. long and 5 ft. 10 in. wide, its weight being 171,000 lb. The core and windings, which weigh about 65 tons, are hung from the cover by a framework and can be lifted bodily out of the containing steel tank. The transformer windings are arranged to step the generator voltage of 6,600 volts up to 30,000 or 60,000 volts for transmission, as may be desired.

Strictly speaking, the transformers are oil-insulated and water-cooled, although no water enters the containing case of the transformer, the oil being cooled outside the case in Worthington surface condensers of a special design. A motor-pump set, consisting of a motor direct-connected to a centrifugal pump on one side for handling oil, and to a second centrifugal pump on the other side for handling water, is installed in duplicate in the basement of the building. Two of the condensers are also installed, and are likewise in duplicate. The oil pump draws warm oil from any transformer into one of the surface condensers through a connection to a pipe header suspended from the ceiling of the basement, and then this same pump delivers the cooled oil to a compartment in the base of the transformer core, from which it rises through the latter and the windings. The overflow pipe from the transformer is equipped with a safety valve which closes if the level of the oil in the tank falls below the point essential for proper insulation. A 5,000-gal. tank placed in a small concrete building on the hillside above the station supplies fresh oil to the system. As this tank is always connected to the oil system a pressure greater than that reached by the water used in cooling is maintained; this arrangement precludes the liability of cooling water entering the oil system. The oil can be drained from any transformer to a 5,000-gal. cooling tank in the basement by gravity through either of two distinct outlet pipes. The latter are both fitted at the transformers with quick acting valves for use in an emergency.

Wiring Scheme. All connections between the bus bars and the various units are made through motor-operated oil switches on the main switching floor over the transformer compartments and the space occupied by the high-tension bus bars. These switches are all arranged for remote control from a benchboard on a gallery which projects out from the switching floor over the middle of the generator room, thus placing the operator in plain view of all the main units. The voltage at this board is the same as that of the exciters. The oil switches are each in a separate compartment, which is built of brick laid in cement mortar and has concrete bottoms and tops. The motor which operates each switch is mounted on the top of the compartment for the latter. The front of each switch compartment is not built up, but is closed by loose asbestos-board doors hung over the openings. The bus bars are all in separate brick and concrete compartments, an opening being left at each support for the buses, in the sides of such of these compartments as are closed. All low-tension wiring is insulated and is laid in conduits in the floors, and carried free up the side walls. The high-tension wiring, which is all bare, is carried on insulated supports, and through porcelain insulators imbedded in concrete blocks, where a connection passes through a wall. A disconnecting switch is placed on each side of every oil switch, in order that repairs may be made with perfect safety.

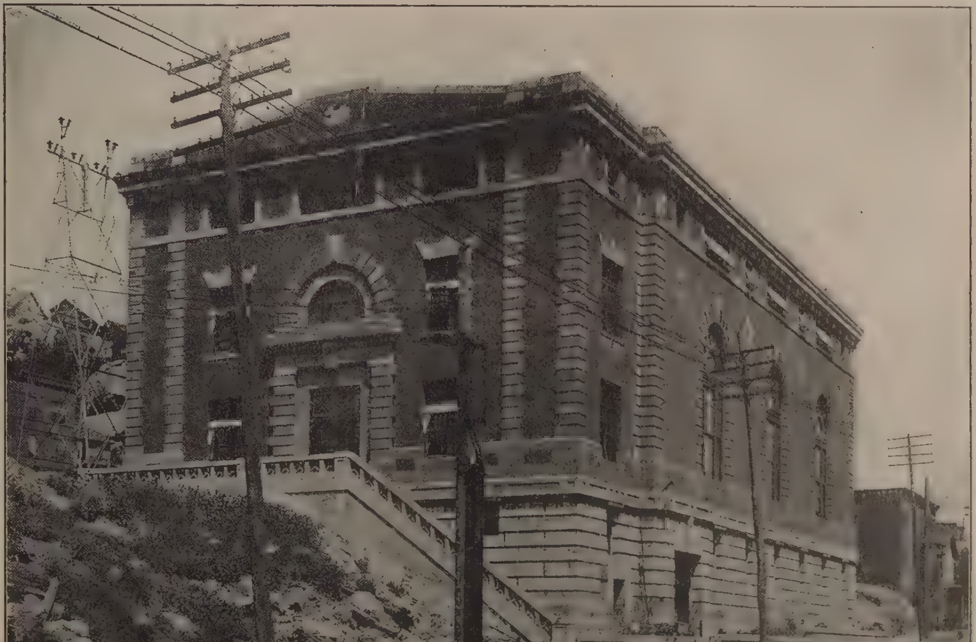

One of the Main Water Wheels Set up in the Shop.

The three main leads from each generator pass through conduits buried in the floor of the generator room to the wall in the rear of the transformer compartments, and then up the rear side of that wall to the switch floor. Three sets of motor-operated oil switches are provided in a separate group on this floor for each generator. The current from the latter is passed through one set of these switches to a set of auxiliary bus bars in compartments built up in connection with the group of compartments containing the oil switches for that generator. From these auxiliary buses the current may be passed through one set of switches directly to the transformer immediately in the rear of the generator, or through a third set of switches to a set of main 6,600-volt bus bars, and from these buses connections may be made to any transformer through motor-operated oil switches. These main 6,600-volt bus bars and the switches which operate them are in a continuous row of compartments on the switch floor just back of the separate groups of compartments for the switches and auxiliary buses for each generator.

The leads from the high-tension side of each transformer are carried through separate compartments immediately under the concrete floor of the switch room to motor-operated oil switches on that floor; these switches are inserted in connections to auxiliary high-tension bus bars placed in separate compartments at the main floor level of the building. These auxiliary buses can be connected through a separate set of motor-operated oil switches to main buses, which are in separate compartments immediately in front of those for the auxiliary buses at the first floor level. Each set of these main buses can be connected to either of two transmission lines that go out of the plant. Each wire of these lines is in a separate vertical compartment built on the rear wall of the building and is provided with lightning arresters and a static discharger. In general the whole wiring system is thus arranged so current from any generator may be passed through any transformer and out through any transmission line, which arrangement is also contemplated to be extended in the future extension of the station.

The power for the auxiliary motors and for lighting in the building is obtained by stepping down a portion of the 6,600-volt current to 440 volts through three transformers in the basement. The switches in the connections to these transformers are also operated by motors controlled from the benchboard.

The switchboard for controlling the ultimate installation of 80,000 h.p. is unusually compact, being not quite 19 ft. in length. The panel for the station lighting and power is placed at the middle of the board, and at each side of this panel are four panels for the eight main units that will be included in the completed station, with a panel at each end for the two exciter units. The panels are of blue Vermont marble, and are set in an ornamental iron frame designed to be in keeping with the remainder of the interior finish of the building. The small switches controlling the motor-operated oil switches are on an inclined benchboard at the front, this board being surmounted by vertical panels for the indicating and recording instruments.


Duluth Sub-Station Showing Architectural Treatment.

Crane. A 60-ton crane, equipped with alternating current motors, spans the generator room and travels the full length of the latter on runways carried by the building frame. The equipment on the floor of that room can thus be reached and hatchways in the floor of the room afford ample opportunity to place equipment in, or to remove it from the basement with the crane. The transformers are on trucks on a track so they can be rolled out under the crane, the front of the compartment for each transformer room being closed by removable doors. A railroad track is also extended into the building on the floor of the generator room.

Transmission Lines. Two three-phase transmission lines, carried on one set of four-legged steel towers, have been built to a sub-station in Duluth, 14 miles from the power station. The towers on which these lines are carried were placed at one side of a 100-ft. right of way, in order to provide space for a second set of towers at the opposite side. The towers are spaced 300 to 1,000 ft. apart, and were built in three heights, 40, 52 and 60 ft., depending on the topography of the country; specially heavy towers were also built at angles in the line. The four legs of each tower converge together at the top in pairs and are thoroughly cross and sway-braced. The two transmission lines are carried at each end of a cross arm at the top of the tower, the three wires of each line being placed at the corners of a 72-in. equilateral triangle.

At present a potential of 30,000 volts will be maintained on the transmission lines, which are No. 00 six-strand copper cables with hemp cores. These lines are designed for 60,000 volts, which will be used when longer transmission is required. A trussed steel pole is extended above the transmission lines on each tower and carries a steel cable of the same size as the copper cables of the transmission lines, as a conductor for lightning protection. This steel cable is grounded at each tower to increase the protection afforded.

A telephone line from the sub-station to the power station is also carried by the towers of the transmission line. The instruments on this telephone line are in booths set on insulators, these booths also being entered from an insulated platform, as protection from effects from the high-tension lines.

Market for Power. The market in short transmission distances from the sub-station in Duluth will consume all of the power that can be furnished by the generating equipment that has been installed. Arrangements have already been made to supply power to the companies which operate the local electric lighting and power stations in Duluth and Superior and for the street railway lines in both of these cities. Various large industrial plants and some of the extensive coal-handling docks along the water front of Duluth Harbor have also arranged to operate on power from the Duluth sub-station. A transmission line has been extended to the waterworks pumping station, from which the distributing system in Duluth is supplied, to operate a motor-driven pump in that station, the latter being a little over 11 miles from the sub-station. The demand for power by these assured consumers will certainly increase very rapidly, since the two cities are growing at a remarkable rate. Additional demands for power will also doubtless be made by other industries already established, and by those which have been contemplated since the inception of the project to develop the St. Louis River. The extensive operations in the Mesabe and Vermillion Iron Ranges, which are within 70 to 90 miles of Duluth, offer a market for power, however, aside from the demands which will doubtless develop in Duluth and Superior, that together with the existing market in those two cities, will, it is believed, eventually, consume more than can be developed on the St. Louis River even when the entire project of the Great Northern Power Co. has been put into execution. At any rate, that part of the development which has been started can scarcely be carried to completion fast enough to meet the power demands certainly in sight.

Sub-station. At present all distributing circuits will be taken from the sub-station in Duluth to which the transmission lines from the power station lead. This sub-station, which is 73x140 ft. in plan, is exactly similar in design and arrangement to the power station. The current from the two incoming transmission lines passes through a wiring system, which is the same as the one in the power station, allowing current from any incoming line to be passed through any transformer and supplied to any outgoing line. Three transformers of the same size and design as those in the power station have been installed. These transformers are arranged to step the incoming current from 30,000 or 60,000 volts down to 13,200 volts. All large consumers of power in Duluth and Superior will be supplied with 25-cycle three-phase current at this potential. The floor of the room in the sub-station corresponding to the generator room in the power station contains three 1,500-kw. motor-driven generator sets which furnish 600-volt direct current for street railway service in Duluth.

Six underground distributing circuits, aggregating about 12 miles of cable, and 16 miles of overhead circuits have been constructed. All important lines have double circuits each capable of carrying the total load supplied by the line. One of these underground circuits extends up the hillside back of the city and thence overhead for 11 miles to the waterworks pumping station. Two others extend about a mile east from the sub-station along the water-front to the power station of the local lighting company. A second two are carried about 1½ miles to a narrow channel across the bay between Duluth and Superior, and thence for 1,200 ft. under the bay in two No. 0000 rubber-insulated and armored submarine cables laid in a trench dredged 30 ft. beyow the low-water level. From the end of these submarine cables the underground circuits are continued about 1¼ miles to a static discharger, and are then continued overhead for about a mile to the power station of the local lighting and power company. Two motor-generator sets, one of 750-kw. and the other of 1,500-kw. capacity, which will supply direct current for operating the street railway system in Superior, are located in that power station. The latter will also be supplied with power from these circuits. A secondary sub-station will be erected later in Superior at the end of the underground circuits where the static discharger has already been installed.

The sixth underground circuit extends west from the sub-station along the water front for about two miles to a static discharger and then overhead two miles farther to two large industrial plants which are to be supplied.

Switchboard in Sub-Station.

The underground work for the two lines along the water front in each direction from the sub-station and for the line to Superior include eight tile ducts each, six of which are available for future use; manholes are placed about 400 ft. apart on these lines with stubs for connection to local consumers. Two three-conductor paper-insulated lead-covered cable, all No. 000, and each having a capacity of approximately 5,000 h.p. at 13,200 volts are laid in each of the circuits. These cables were made and installed by the Roebling Sons Co., of Trenton, N. J. The overhead construction consists of a pole line carrying two circuits and can be framed for four circuits. The poles are placed about 125 ft. apart and are 50 to 60 ft. in height carrying the lines above all those which are crossed; such local wire lines as are crossed are protected by guard wires.

Methods Used in Construction. The power company built a standard-gauge track 3½ miles long, from the end of a branch of the Northern Pacific R. R. to the power station, for use in delivering the materials required in construction at the power station and in that vicinity. The equipment for the station was also delivered over this railroad, which will be permanently maintained. The plant and materials required in building the service reservoir and the upper works of the development were brought in on the line of the Northern Pacific R. R., which crosses the channel. A spur track was extended from this railroad directly to the site of the main dam and greatly facilitated the delivery of materials for that dam and for several of the other adjacent smaller dams.

Although the project involved a large amount of construction work in the aggregate, the work was so evenly distributed that outside of the main dam and the power house no very great opportunity was presented to employ extensive construction plant. The main dam was built in a manner, however, that greatly facilitated its construction. The spur track from the railroad was carried up on a trestle that extended over the site of the retaining wall at one end of the dam and approximately at right angles to the spillway of the latter. A concrete mixing plant was erected at one side of this trestle, the sand and gravel used in the concrete being dumped from cars on the trestle into separate stock piles under the latter. A trench 6x6 ft. in cross section and about 200 ft. long, had been built under the site of the stock piles previous to the delivery of any materials, and was timbered over so as to form a tunnel under the piles. A belt conveyor placed in this tunnel was fed through chutes in the tunnel roof and delivered at the end to the boot of a bucket elevator. The supply chutes were placed at convenient intervals and were controlled by cut off gates. The bucket elevator was arranged to deliver to either of two storage bins erected over the 1 yd. Chicago cubical concrete mixer which was installed, one bin being provided for gravel and one for sand. Cement was stored in a shed close to the mixer plant and was raised to the charging platform of the latter by a bag elevator.

A 1,000 ft. span Flory cableway, on 70-ft. towers was erected on the long axis of the spillway and spanned all of the straight part of the dam. The concrete mixer discharged into 1-yd. skips on flat cars on a narrow-gauge track that extended from the mixer to the path of the cableway, these skips being picked up and carried to place by the latter.

The main dam, and in fact all concrete dams were built in alternate 30 ft. sections with a tongue-and-groove expansion joint extending entirely through the dam at the junction of each two sections. The retaining wall containing the three 7x9-ft. sluice gates and about half of the spillway section adjoining it were built first, a cofferdam being used in the river. The latter was later diverted through the sluice gates while the remainder of the dam was being built in a second cofferdam.

Concrete mixers were also used in building practically all of the other concrete structures included in the development, and, where feasible, plants for handling the materials were installed. Much of the concrete work on the dam and power house was laid in the winter when the temperatures frequently reached several degrees below zero Fahr., but all of it placed under such conditions is perfectly satisfactory, due chiefly to two reasons. First, the concrete materials and the water, were all heated by steam coils before being mixed, and after the concrete had been placed it was covered with canvas, under which fires were constantly maintained in salamanders until the concrete had received considerable set. Secondly, the weather remained uniformly cold until after the concrete was of considerable age, so no alternate freezing and thawing occurred.

View of Main Dam under Construction.

In all, over 50,000 cu. yd. of concrete was used in the various structures connected with the development. The proportions of the concrete were varied continually to suit the materials, an endeavor being made to always secure about 10 per cent. surplus of mortar. Universal Portland cement, about 60,000 bbls. of which was required, beach sand and lake gravel were used exclusively for concrete, except at the lower head gates, where satisfactory gravel was obtained from the excavation. A laboratory was maintained on the work to test the cement daily and to determine the character of the sand and gravel, so the concrete mixture could be varied properly. In all of the cement used none was rejected. The sand was of excellent character, varying uniformly from quite fine to very coarse, and the gravel had the same quality, so the two formed an excellent combination, the voids in the latter frequently being only 20 per cent., or less.

The canal and forebay were built with four steam shovels and narrow-gauge dump cars handled by light locomotives, the total excavation in the canal being over 400,000 cu. yd., of which 100,000 cu. yd. were rock. Two stiff-leg derricks were also used in a part of the work where the material from the excavation was wasted.

The project to develop the St. Louis River, according to the plans which have been followed, was conceived by Mr. F. A. Cokefair, chief engineer of the Great Northern Power Co., and it is largely due to his efforts that the project was carried out. Mr. C. C. Cokefair, president of the Great Northern Development Co., organized the Great Northern Power Co. and financed the project. Mr. C. A. Duncan is now president, and Mr. E. P. Coleman is general manager of the company. Capt. Alex. McDougall is a director of the company and has been actively interested in it since its inception. In addition to local capital that is interested in the company, Messrs. Chas. D. Barney & Co., of New York, and Tucker, Anthony & Co., of Boston, are managers, and the Knickerbocker Trust Co., of New York, is the trustee of the company. Mr. F. O. Blackwell, of Messrs. Viele, Cooper & Blackwell, consulting engineers, of New York, is consulting engineer for the company. During the design and construction Mr. E. C. Bacot was in charge of the electrical engineering department of the company and Mr. W. D. Rittenhouse, mechanical engineering department, under the supervision of Mr. F. A. Cokefair. The power station and sub-station were designed by Mr. A. H. Albertson, architect, of New York.

View of the Transmission Line.

The contract for the construction of all such parts of the development that have been built was awarded to the National Railway Construction Co., of which Mr. Thos. Pettigrew is chief engineer. This company sub-let some parts of the construction work, but built the most important structures. The principal sub-contractors, in addition to those which have been mentioned, were Messrs. Truax & Thomas, who built two of the reservoir dams and the 3½-mile railroad, and Mr. J. W. Hilliard, who erected the sub-station. The electrical equipment for the entire project was furnished and installed by the General Electric Co. The hydraulic apparatus was built and erected by the Allis-Chalmers Co.

Lightning Protection for Chimneys.

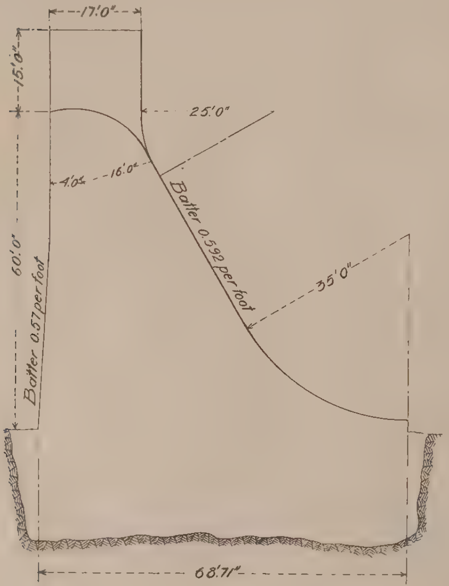
Standards for lightning protection for power plant chimneys in the Navy Yards have been adopted by the U. S. Navy Department, the proposed means being varied for different heights of chimneys to cover those found in the different yards. It is specified that the conductors shall each be made up of seven No. 10 copper wires, two in number for chimneys up to 50 ft. in height, three for chimneys between 50 and 100 ft., and four in number for those higher than 100 ft., in all cases being symmetrically disposed around the stack and forming a cage enclosure. They are to be fastened firmly without insulators to the outside chimney surfaces by bronze anchors, the latter being spaced 10 ft. apart and soldered to the conductors at 50-ft. intervals. At the bottom of the stack the conductors connect with 3 ft. x 3 ft. x ⅛-in. copper earth plates buried in the ground below the water line, and at the top to a 1½ x 1½-in. copper ring, to which the discharge tip rods are attached. The latter are of ¾-in. solid copper, 10 ft. in length, spaced 4 ft. apart around the circumference of the chimney cap, each terminating in a two-pointed aigrette. The portions of the conductors near the chimney base are to be protected by a 1½-in. galvanized-iron pipe sheathing, rising 10 ft. above the ground level and extending 3 ft. below it.

The Concrete Mixing Plant at the Main Dam.

The New Water and Sewerage Systems of Manila.

Early in 1906 the municipal board of Manila, P. I., let contracts for a sanitary sewerage system, and a large addition to the water supply of the city. The work is now well under way and it is expected that the water supply system will be completed about the middle of next year, and the sewerage system about a year later. The new water supply is to be taken from the Mariquina River, about 16 miles northeast of Manila, and will be brought to the city partly through a riveted steel pipe line and partly through a free flowing conduit. The work necessitates the construction of a dam at a gorge in the river, creating a reservoir with a capacity of about 2,000,000,000 gal., and the construction of a distributing reservoir about a mile from the present one. The sanitary sewerage system is to be extended to all parts of the city, and on account of the low elevation will consist of a combination of gravity and pumping systems.

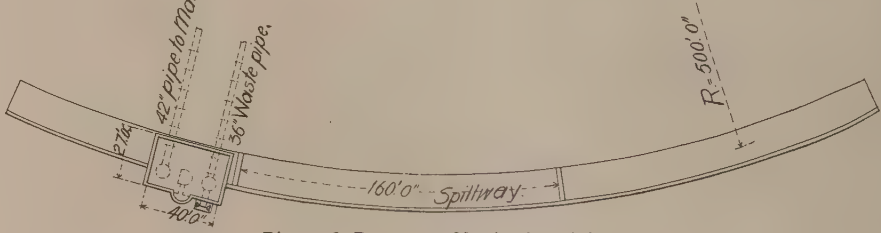
The dam which will create the impounding reservoir has a length of about 400 ft. on the crest, the central portion, 160 ft. in width, being designed as an overflow or waste weir with its crest 15 ft. lower than the remainder of the dam. The maximum height above the bed of the stream is approximately 75 ft. The elevation of the reservoir is about 212 ft. above sea level.



Spillway and High Sections of Dam.

The foundation of the dam is a bed of solid rock which was thoroughly cleaned of all dirt and debris and washed before the work was started. The bonding of the masonry to the foundation was further secured by stepping and grooving the rocks after all fissured and unsound portions had been removed. The excavation for the foundations amounted to about 16,000 cu. yd., 11,000 of which consisted of solid rock.

The dam is built of rubble concrete masonry containing about 50 per cent. of large stones laid in irregular fashion so as to avoid continuous joints through the structure. The stone is a marble—a high grade of limestone. The concrete is a 1:2½:5 mixture, the aggregate being gravel and broken stone, in sizes varying up to 2 in. in maximum dimension. The sand, gravel and stone were obtained in the vicinity of the dam. The upstream top and downstream faces are built of coursed-rubble made with stone, dressed so as to make ¾-in. joints, for a depth of at least 4 in. After laying the joints were raked out to a depth of 2 in. and pointed with a 1:1 cement mortar. The total yardage of the dam including large stones and concrete is about 28,000 cu. yd.



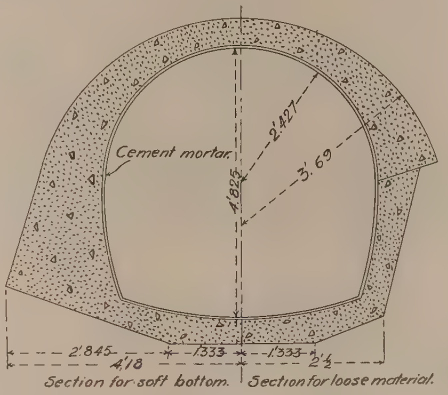
Plan of Dam on Mariquina River.

The gate house controlling the flow from the reservoir to the pipe line is built as part of the dam at one end of the spillway section. It measures 27x40 ft. in plan, the longer dimension being parallel to the axis of the dam. Two pipe lines run through it, one a 42-in. line carrying the supply to the city and the other a 36-in. pipe serving as a waste line and discharging into the river a short distance below the dam.

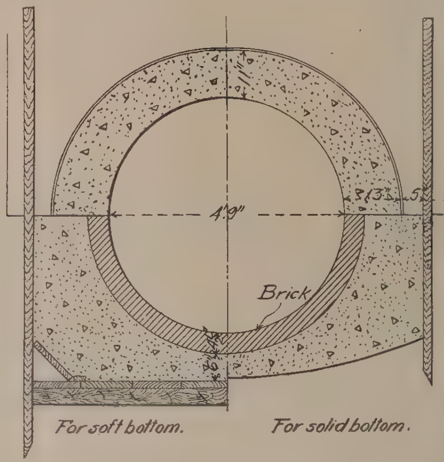
The pipe line consists of a 42-in. riveted steel main 10½ miles long, discharging at the end nearer the city into a conduit which follows the hydraulic gradient. For about two miles it follows the valley of the Mariquina River and then starts across country in a direct line for Manila, passing under the Mariquina River through a 36-in. cast-iron pipe. Through all parts of its length it is between 50 and 100 ft. below the hydraulic gradient, a depth of about 100 ft. being maintained for all but a short distance of the line. The pipe is made of plates about 2/10 of an inch thick of 2 courses, the smaller fitting into the larger, each course corresponding to the width of plates from which the pipes are made, being about 60 in. long. The longitudinal seams are double riveted and the circular seams single riveted, except at curves where circular seams are double riveted at the beveled joints, the rivets used being 7/16 in. in diameter. The pipes are fabricated at the shop of the Atlantic, Gulf & Pacific Co., in Manila, and transported to the work in sections 20 and 30 ft. long, depending upon the transportation facilities and the condition of the roads. The steel plates for the pipe were furnished by Henry H. Peabody & Co., having been purchased by the Municipal Board of Manila under contract awarded at the time of letting the remainder of the work. The pipe is caulked at all seams inside and out before being coated, and tested at the shops to a hydraulic pressure of 100 lb. per square inch. After being laid in the trench, the pipe is again tested, the field riveting having been completed, to a pressure of 75 lb. per square inch. Blow-off pipes are provided at all sags in the line, and air valves at all summits, these in all cases being enclosed in suitable wells. The blow-off pipes are 6 in. in diameter and are discharged into convenient water courses. Brick manholes, 14x16 in., are spaced approximately 500 ft. apart throughout the entire line. The excavation for the pipes lines amounted to about 58,000 cu. yd. of earth and 18,000 cu. yd. of loose, solid and adobe rock. The minimum covering of the completed pipe is 2 ft.

The crossing under the Mariquina River near San Mateo is made through a 36-in. cast-iron pipe about 500 ft. long at each end of which reducers join on to the 42-in. riveted steel pipe in gate houses through which the valves controlling the 8-in. blow-off pipes are controlled. These gate houses are circular, 8 ft. in diameter, and surmount the 6-ft. concrete wells in which the valve mechanism is set.

From the end of the pipe lines to the distributing reservoir, water flows through a concrete aqueduct constructed in tunnels the entire distance of 4 miles. Part of the work is done by the cut and cover method, but the greater part by tunneling carried on from 12 shafts. The total amount of earth and rock to be moved is about 34,000 cu. yd., most of which is adobe rock. The conduit has a horse-shoe section about 4½ ft. wide and a maximum height of 4 ft. 10 in. In solid rock sections the conduit is lined with a coat of 1:1 cement mortar, while in those parts where a full concrete section is required the same mortar finish is applied to the concrete. Where the line runs through loose material or a soft bottom is encountered, the concrete is spread out to afford an adequate foundation, and in places where the conduit runs through a section of rock overlaid with loose material the cut and cover method is used, excavating the lower part of the conduit in solid rock and building a concrete roof having the same interior arch as the other sections. The minimum thickness of concrete at the crown of the arch, is 6 in.



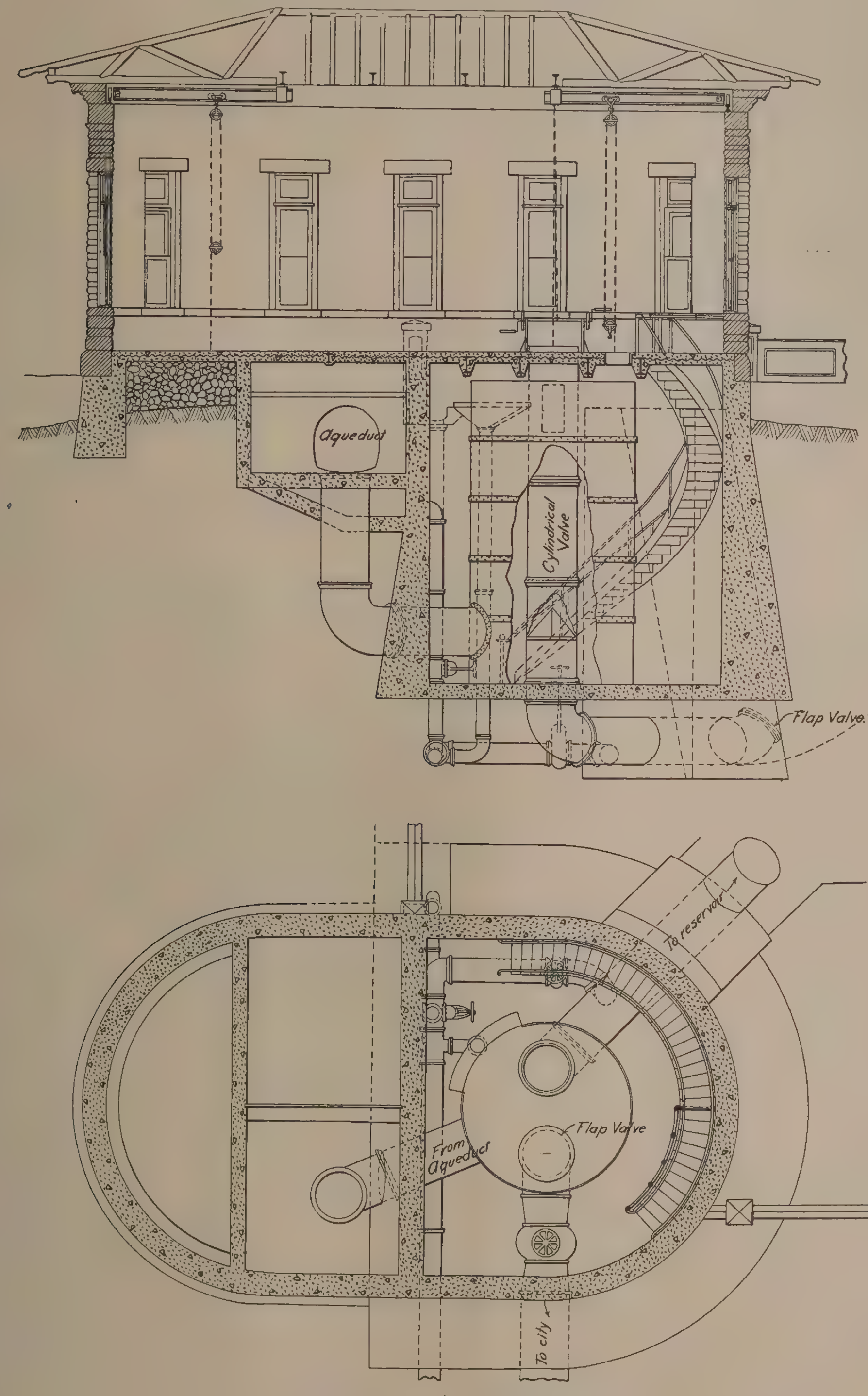
Sections of Aqueduct.



Sections of Concrete Sewers.

The siphon is composed of two 42-in. cast-iron pipes connected to the conduit by means of concrete siphon chambers, 8 ft. wide and 8 ft. high, to which access is had by means of 24-in. manholes.

The distributing reservoir is located about a mile east of the present Deposito, as the present reservoir is called, and 1½ miles outside the city limits of Manila, at an elevation of about 112 ft. above the level of the sea. It is rectangular in plan, measuring 504x769 ft., 20 ft. deep, and has a capacity of 50,000,000 gal. It is built on ground sloping to the south with a maximum difference in elevation of 15 ft. The bottom of the reservoir is about 25 ft. below the natural surface where the ground is highest, and about 8 ft. where it is lowest, and consequently the greater part of it lies in excavation and only part of the banks are carried up above the natural surface. The banks slope 1:1 and in the rock section are covered with a thin coating of cement mortar while the other parts of the banks are lined with a 4-in. layer of 1:2½:4 concrete. Expansion joints are left in the lining every 20 ft. Where the top of the reservoir is above the natural surface of the ground an embankment is built up in the customary manner, laying thin layers of good earth and watering and rolling them thoroughly. A 10-ft. driveway on a 10 per cent. slope leads down inside the embankment so as to allow access to the bottom of the reservoir for wagons should it be necessary to make repairs. The excavation here involved amounted to 29,000 cu. yd. of earth and approximately 235,000 cu. yd. of rock.



Gatehouse at New Reservoir.

The water supplied to the conduit is measured before entering the reservoir over a weir built into a concrete chamber which is surmounted by a suitable building. The weir box is 12 ft. wide and 29 ft. long from the end of the conduit to the weir. The weir itself consists of a steel plate bolted to plates set into the concrete of the chamber, the notch being 6 ft. wide and 2 ft. deep. The crest is approximately 3 ft. 3 in. above the bottom of the chamber. A 20-in. drain pipe controlled by a gate valve allows the silt that may accumulate in the chamber to be flushed out.

The flow into and out of the reservoir is controlled from a single gate-house located at the corner of the dam toward Manila. The aqueduct, the gates of the reservoir and the supply pipe leading to Manila all meet in a riveted steel distributing tank and are fitted with suitable valves so as to divert the flow as desired. The aqueduct enters immediately below the floor of the building, which is on a level with the top of the embankment, and terminates in a concrete chamber across one end of which is a screen shutting off a second chamber, from which a 42-in. cast-iron pipe leads down to discharge into the tank near the bottom of the latter. The discharge into the reservoir from the distributing tank is controlled by a cylindrical valve, and by a flap valve on the end of the pipe in the reservoir. The flow into the main leading to the city is governed by a flap valve which can be raised by mechanism on the floor of the gate house, and by a 36-in. gate valve located outside the steel tank in the concrete chamber. A 12-in. overflow pipe is attached to the tank and an 18-in. drain pipe is connected with the line connecting the tank and the reservoir.

The gate house is built with semi-circular ends 47 ft. 8 in. on the longest and 26 ft. 8 in. on the shortest dimension. It is built of ashlar masonry laid in Portland cement mortar, and the interior is finished with Mariquina marble. The water will be conveyed to the city from the new reservoir in a 42-in. cast-iron pressure pipe, the supply in the city being wholly by gravity due to the elevation of the reservoir.

Sewerage System.—Up to the present time Manila has been without a sewer system and the one now being built is a sanitary system, a distinct arrangement of open drains being projected to care for the storm water. The ground on which the city is built is very flat and varies in height above mean high tide from 2 or 3 to about 10 ft., and for this reason a purely gravity drainage system was out of the question. The natural solution of the problem of the disposal of the sewage was to discharge it into the bay at such a point where it would not be obnoxious and this plan has been adopted. The city has been divided into 6 districts, 3 on each side of the Pasig River, in each of which an independent gravity drainage system will be installed. The sewage of each district will drain to a pumping station from which it will be forced to the main pumping plant located on the shore of the bay at the beginning of the force main through which it will be discharged. All of the sewage from the three pumping stations on the south of the river will be carried under the river to the main pumping station through a twin inverted siphon consisting of two 24-in. flexible joint, cast-iron pipes.

There will be in all about 52 miles of sewers, 7½ miles of which will be composed of brick and concrete, ranging in size from a 2 x 3-ft. egg-shaped to a 4¾-ft. circular section, laid at depths ranging from 12 to 18 ft. below the surface of the ground; and about 42 miles of glazed terra-cotta pipe from 8 to 24 in. in diameter, laid from 5 to 16 ft. below the surface. In addition to these lines, there will be one 42-in. cast-iron outfall pipe, 6,500 ft. long, laid below the bed of the harbor, the crossing of the Pasig River above mentioned, and cast-iron pipe crossings of 9 esteros or canals.

The sewers are laid throughout in loose material, consisting of mud, sand and light clay, the sides of the trenches requiring very careful sheeting to retain the soft material. Pumping has to be done continually while the work is in progress. Much of the sheeting is left in place in order to prevent the caving of the streets beside the trench after the latter is refilled. The large sewers are built of concrete, with a single layer of brick laid in the concrete to form the invert. In the egg-shaped sewers a moulded concrete block replaces the brick in the sharp curve at the bottom of the invert. In insecure foundations the sewers are supported on timber platforms. The lower half of the terra-cotta sewers is surrounded with an annular ring of concrete from 4 to 6 in. thick, depending upon the size of the pipe, and where the foundation is not firm, the concrete instead of being placed as a ring is spread out so as to afford a footing and placed upon a timber foundation the same as for the large sewers. The Portland cement used both on this work, and on the water-works system is of English make, K. B. & S., and White Bros.

The estero crossings are made by double lines of cast-iron pipe ranging in diameter from 16 to 36 in., the pipes in all cases going well below the bed of the canal. On each bank there is constructed a chamber, to which access is had through a manhole, in one of which are located gates for shutting off the flow in the pipe. In some cases where only one pipe was necessary a safety outlet has been provided through an extra chamber whereby the sewers can be diverted into the estero in case it is necessary to make repairs to the pipe. By closing a gate dividing the two chambers, the sewage is forced through the temporary discharge pipe which opens from this chamber. The second chamber is therefore left free and can be drained to afford a working place in putting cleaning devices through the pipes or making repairs. The pipes, whether single or double, are completely enclosed in concrete and where the soil requires it are placed on timber platforms. These estero crossings vary in length between man-holes on the banks from 84 to 223 ft. The crossing of the Pasig River is built of two 24-in. flexible-joint cast-iron pipes laid with their tops about 23 ft. below mean low tide level. The crossing is about 650 ft. long between the man-holes on the banks. These crossings of the esteros and the river were put in by dredging trenches, and lowering the pipe from barges.

The outfall pipe leading under the bay consists of a 42-in. cast-iron pipe with bell and spigot ends, 6,500 ft. long, supported on piles 9 ft. apart throughout the entire length. The piles are capped with a 10 x 10-in. timber, 6 ft. 6 in. long, and every 18 ft. additional piles were driven on both sides of the pipe to hold it against lateral movement.

The bay is quite shallow where the pipe runs, the water being from a few feet to about 8 ft. deep at mean low water. The pipe was laid in a trench excavated by a hydraulic dredge and after it was in place and calked the trench was refilled. The pipe was put together in sections 48 ft. long, consisting of four 12-ft. lengths, and loaded on barges and towed out to their position. The barges were brought up alongside a scow on which four tackles were rigged for lowering the pipe to place. The pipe was calked with oakum and soft lead by divers. The end of the pipe is located in 8-ft. of water in a concrete block 14 ft. square and 12 ft. high, resting on a timber platform built on piles.

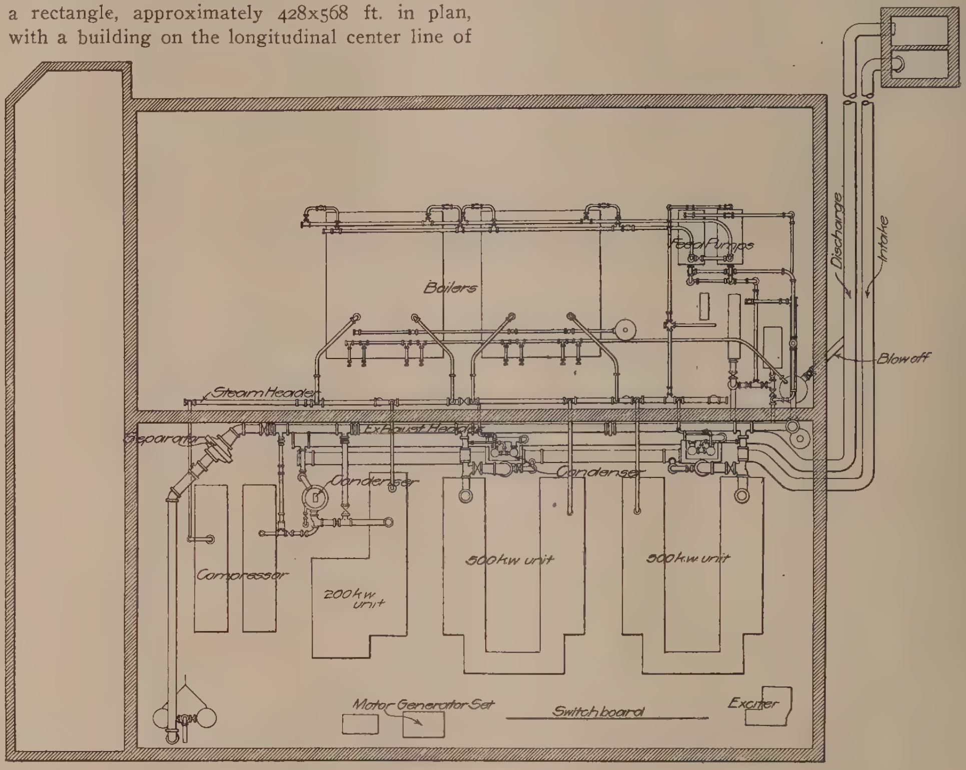
The amount of the contract for the water-works system is $1,026,000 and for the sewerage system $1,631,000. The work is under the Department of Sewer and Water-Works Construction, the water system being designed and in charge of Mr. J. F. Case, chief engineer of the department. The sewer system was designed by Mr. O. L. Ingalls, principal assistant engineer of the department. At the present time the sewerage system is 50 per cent. completed, the tunnels 75 per cent., and the riveted steel pipe line 33 per cent.

The steel pipe and tunnel of the water-works system, and the entire sewerage system are being built by the Atlantic, Gulf & Pacific Co., and the dam and reservoir by the Matson, Lord & Besler Co.

A Large Deposit of Iron Ore has been discovered on the Island of Cuba, in the Province of Oriente. It is located on a plateau ten miles long by about four miles wide. A large number of borings have been made and the property involved, about 27,000 acres, has been secured by a company that is about to develop it.

The Power Plant of the Elgin National Watch Works.

The manufacturing works of the Elgin National Watch Co. at Elgin, Ill., are in a group of large factory buildings on the left bank of the Fox River. The original buildings of these works were not arranged according to any defined plan, but had been added from time to time as more space was required. Several years ago after the business of the company had grown to large proportions, a broad general plan for the complete arrangement of the works was adopted. This plan contemplated that most of the old buildings should be abandoned and replaced by new ones, which could be arranged to better facilitate the operation of the works. The new buildings were to be placed around the sides of a rectangle, approximately 428x568 ft. in plan, with a building on the longitudinal center line of the rectangle. A part of this plan has been carried out by erecting new buildings along the front side and one end of the rectangle, and by abandoning some of the original buildings.



General Plan of Power Station.

The new buildings that have been completed are four stories and a basement in height, their design conforming to the uniform proportions of the general plan. They are of fire-resisting construction throughout and are built to produce the best of light and ventilation for the large number of employes housed by them. The greater part of the manufacturing carried on in these buildings is exceedingly intricate, but a considerable amount of work is done by machines which, together with the lighting, heating, ventilating, and service systems for the various buildings, necessitate a large power plant capable of responding to a load which varies widely from hour to hour and from season to season.

The original power plant of the works was in two brick buildings near the center of the rectangle of new buildings. The demands for power had gradually outgrown the capacity of this plant until the equipment of the latter was no longer equal to the requirements, although such additions as were feasible had been made to it from time to time. A plan for an entirely new plant arranged to provide for the growth of the works was therefore adopted and carried out.

The new power plant is in a separate brick building at one corner of the proposed rectangle of new factory buildings. The end of this building is in line with the buildings along the end on the river side, and the front of it is about 100 ft. from the site of the buildings which will occupy the rear side of the rectangle. The exterior of the power plant building conforms with the design of the new factory buildings. It is 108.5x 115 ft. in plan and rises to a height of 61 ft. above the footings. The building has a concrete substructure built on solid rock. The side walls are of buff brick, trimmed with Bedford sandstone and ornamental terra cotta. The roof is carried by steel trusses resting on the side walls. The interior of the building is divided by a longitudinal brick wall into an engine room, 53 ft. 11 in. wide, and a boiler room 49 ft. 6 in. in width, a basement 11 ft. in height extending under the entire building. The basement has a concrete floor and the floors of the boiler and engine rooms are of reinforced concrete.

Coal for the plant is delivered by the Chicago & Northwestern Ry. and the Aurora, Elgin & Chicago third-rail electric line, the latter connecting with the Illinois Central and the Chicago, Milwaukee & St. Paul Railroads. An elevated switch track is extended from these lines over a track hopper at one end of the building. The coal is handled from this hopper to overhead storage bunkers in the boiler room by a traveling Link Belt gravity-overlapping-bucket conveyor, with a capacity for handling 40 tons an hour. The coal feeds by gravity from the track hopper into a crusher, belt-driven by a 15-h.p. induction motor in the basement of the boiler room. The conveyor is driven by a 7½-h.p. induction motor in a tower over the track hopper at the end of the building. It extends vertically up the end of the building from the crusher to the top of the boiler room, then horizontally the length of the latter, down at the opposite end of the room to the basement and thence in a horizontal run along the floor of the basement to the crusher again.

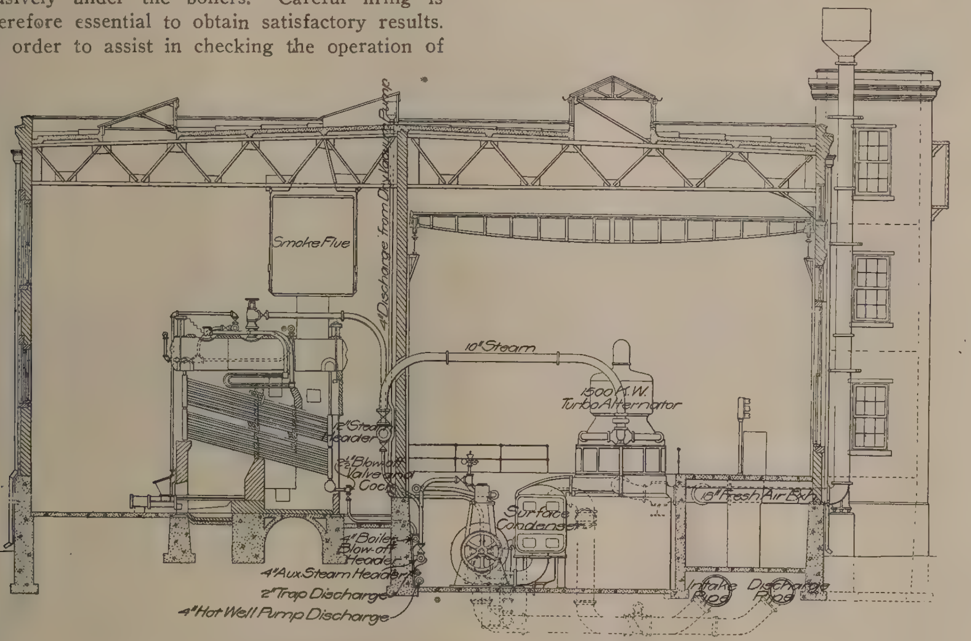
The boiler room contains four Cahall horizontal sectional water-tube boilers, which are placed in pairs in a row, with space at one end of the row for an additional pair. Each boiler is equipped with a Mansfield traveling chain-grate stoker, 6 ft. 5 in. wide. The coal conveyor delivers to four overhead storage bunkers, with a capacity of 1,000 tons, one for each of the present two pairs of boilers, one for each pair that will be installed in the future and one for storage. The bunkers each have two downspouts, one for each of the two boilers of the pair which they serve. The downspouts are controlled by undercut gates, and feed directly into the charging hoppers of the stokers. The coal which falls through the front ends of the stokers is caught in a hopper built in the concrete floor in front of each stoker. These hoppers are covered with an open grating and extend down to the horizontal run of the conveyor in the basment, so the coal which reaches them may be elevated to the bunkers again. The ashes fall from the rear end of the stokers into a pit built in the setting below the floor level of the boiler room. These pits are also connected by a chute with the space back of the boiler arch, so the fine ashes and soot caried over into that space can be removed through them. The run of the conveyor in the basement is placed close to the fronts of the boiler settings enabling the ashes to be drawn into it from the pits. The conveyor delivers the ashes to a storage bin over the track at the end of the building, from which they can be fed by gravity into cars on the track.

Washed Illinois screenings, containing from 10,000 to 11,000 B. t. u. per pound, are burned exclusively under the boilers. Careful firing is therefore essential to obtain satisfactory results. In order to assist in checking the operation of the stoker an Ados CO_2 recorder has been installed to analyze the flue gases. This instrument is placed in a tight wooden booth against the wall directly in front of the boilers where the firemen can see it at all times. A door is built in each side of the booth to permit the removal of the recorder. A double door in the front of the booth is provided at the top with a glass so the operation of the recorder may be observed without opening the larger front door. Gas is furnished to the recorder from the flue leading from the boiler to the stack by a device which insures a fresh supply for each analysis.

The recorder can be set so it will make and record automatically the results of analyses at various intervals, but in this case an analysis is made every 5 minutes. The results obtained are recorded on a strip of paper carried by drums moved by clock-work similar to a recording steam or water-pressure gauge. From the results thus obtained the percentage efficiency of the furnaces can be readily calculated.

When the recorder was placed in operation in June, last, the efficiency of the furnaces was found to be about 70 per cent., that is to say, 30 per cent. of the heat value of the coal was being lost up the stack. After the recorder had been in use about four weeks the loss was reduced to 15 per cent., due to greater care used by the firemen and to changes which had been made in the grates. The incentive given the firemen by the constant check on their work afforded by the recorder and the opportunity to observe the results of different methods of firing are considered to be the chief reasons why better firing is obtained.

Exterior of Power Station.

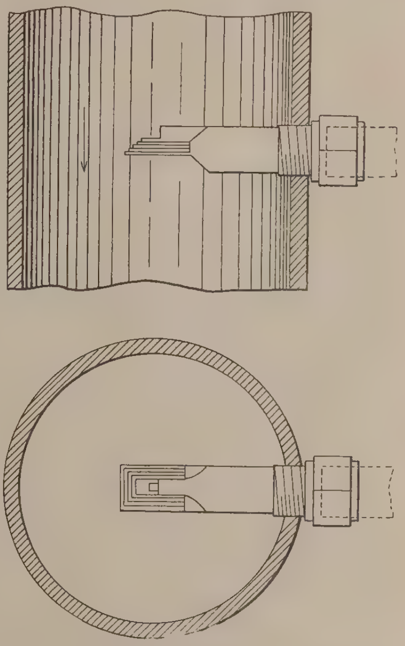

Smoke Flue
4" Discharge from Duplex Pump
10" Steam
1500 K.W. Turbo Alternator
12" Steam Header
2½" Blow-off Valve and Cock
4" Boiler Blow-off Header
4" Aux. Steam Header
2" Trap Discharge
4" Hot Well Pump Discharge
Surface Condenser
18" Fresh Air Exh.
Intake Pipe
Discharge Pipe

Cross-Sectional Elevation of Power Station.

The boilers embody no special features of design. They are rated at a combined efficiency of 64 per cent., when producing 300 h.p. each at 180 lb. pressure and on the washed screenings used; and a combined efficiency of 58 per cent., when producing 450 h.p. each, under the same conditions. Feed water is supplied to them from a Cochrane feed-water heater, on an elevated platform at one end of the boiler room, by either of two Prescott duplex feed-water pumps. These pumps are also arranged so they can draw cold water from a suction main connected directly with the river. A service pump in the basement of the boiler room supplies river water to the heater. Duplicate delivery lines from the feed pumps are carried over the front end of the boiler settings and are cross-connected at each of the four boilers, so any of the latter may be supplied from either line.

The two drums of each boiler are connected to a 9-in. steam header along the rear wall of the boiler room. This header is connected at each end to a 6-in. auxiliary header in the basement of the boiler room, forming a ring system. The main steam-consuming units in the basement of the boiler room are supplied from the 6-in. auxiliary header.

The engine room contains three main generating units, an air compressor, a steam-driven and a motor-driven exciter set, a motor-generator set and a 15-ton Whiting hand-operated crane. One of the main units consists of a 22x36x42-in. McIntosh-Seymour cross-compound engine, direct-connected to a 500-kw. Crocker-Wheeler 60-cycle 225-volt 3-phase alternating-current revolving field generator, operating at 100 r. p. m.; the other main unit is the same as the first, except that its low-pressure steam cylinder is 40 in. instead of 36 in. in diameter. This difference in the two engines was made in order that the second unit could operate non-condensing more economically.



Cylinder Lubricating Device.

The buildings of the works are heated by the Paul and the Webster exhaust steam systems, which are supplied chiefly from the non-condensing main generating unit. The latter, however, can be operated condensing, if desired, as each main unit is equipped with an Edwards twin vertical jet condenser. Normally, the condensing main engine carries the day load during the months when the heating system is not in service, or when it can be supplied with exhaust steam from the smaller steam-consuming units in the plant; and the non-condensing main unit carries the load at other times. The night load is carried by the 200-kw. generating unit, for, although a considerable portion of the machines in the works which require power are run continuously, most of the buildings of the works are closed at night, thus relieving the load due to lighting, heating, ventilating and service. This third unit consists of a 13x22x30-in. McIntosh Seymour Corliss tandem-compound engine direct-connected to a 200-kw. Crocker-Wheeler generator of the same type as the generators of the two large units, but operating at 150 r. p. m. This unit is equipped with an Allis-Chalmers vertical jet condenser, and is designed to operate condensing. The motor-driven exciter consists of a 50-h.p. induction motor driving a 30kw. 125-volt direct-current General Electric generator. The steam-driven set has a 50h.p. McIntosh-Seymour high-speed engine direct-connected to a Crocker-Wheeler generator of the same capacity as the other, both units running at 300 r. p. m.

All three engines are designed to run on steam at 180 lb. pressure, and are equipped with non-releasing valve gears. The large engines can each develop 750 h.p. at one-fifth cut-off; 1,160 h.p. at one-half cut-off; and 1,378 h.p. at seven-tenths cut-off. They were also built under the following speed regulation guarantee: with steam at 160 to 180 lb. pressure and a variation from no load to the full rated load of 750 h.p., or vice-versa, the revolutions per minute shall not vary more than 2 per cent.; with the same variation in steam pressure and changes from no load to a load of 1,160 h.p., or vice-versa, the speed variation will not exceed 6 per cent. of the normal.

The three condensers for these engines are supplied with cooling water through a 24-in. main leading from an intake in the river. A screen chamber covered by a small brick building is placed on this injection main near the intake. The discharge from the condensers is carried back to the river by a 24-in. main that passes through a chamber in the sub-structure of the screen chamber building and terminates at the intake. A manhole provides means of entering this chamber on the discharge main. The blow-off from the boiler is also carried to the chamber on the discharge pipe.

The air compressor in the engine room is of the two-stage cross-compound type, with a capacity of 500 cu. ft. of free air a minute, when operating at a 100 lb. pressure. This machine delivers to two receivers in the basement of the engine room. The air is piped to all parts of the works, in which it is used for a multitude of purposes in connection with the manufacturing processes.

The motor-generator set consists of a 100-h.p. alternating-current induction Crocker-Wheeler motor direct-connected to a 75-kw. 220-volt direct-current generator. The latter supplies power for operating direct-current motors for elevators in the various buildings, and for a few direct-current motors in different parts of the works.

The operation of the electrical units is controlled from a switchboard at one side of the front of the engine room. This board has sixteen panels of blue Vermont marble and is equipped with General Electric apparatus and instruments. A panel is provided for each of the main generator units, one for the two exciters, one for the motor and one for the generator of the motor-generator set and a totalizing panel. The remaining eight panels are each for one of the eight circuits into which the distribution system is divided.

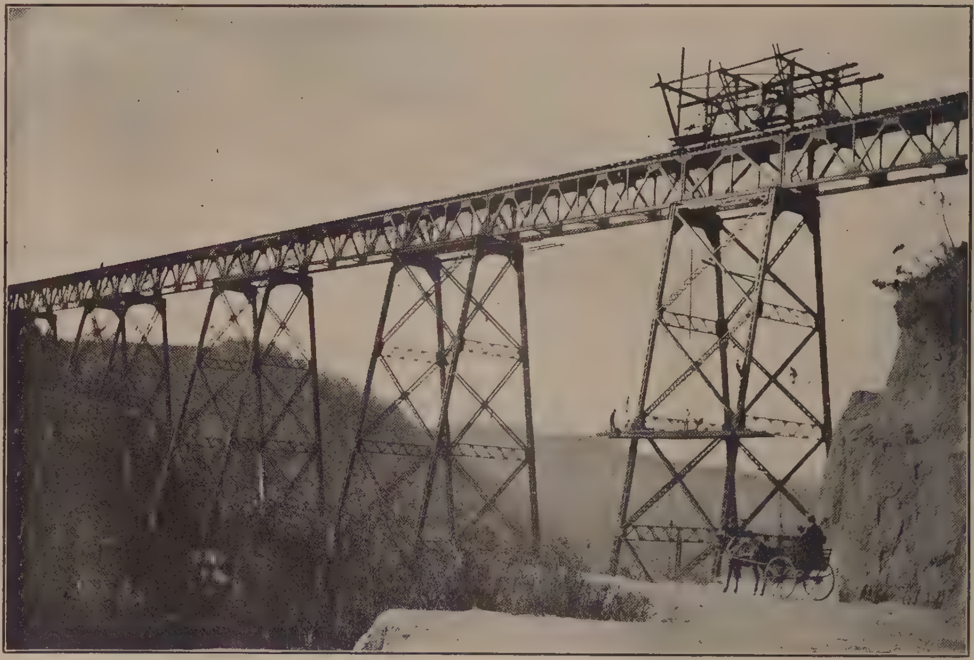
The exhaust-steam heating system is supplied from an 18-in. header extending the full length of the basement of the engine room. The exhaust of all of the steam-consuming units in the plant are connected into this header. A riser extends from one end of the latter to an exhaust head above the roof. The feed-water heater in the boiler room is connected to a by-pass on this riser, in order that it may or may not be supplied with steam from the exhaust system. The exhaust riser is equipped above the by-pass to the heater with a back-pressure valve, a 6-in. air vent leading from just above this valve to a blow-off tank in the basement.

A 26-in Crane horizontal oil separator is placed on the 18-in. exhaust main just beyond the last connection with a steam-consuming unit. The oil and water removed from the steam by this separator are passed through a second specially designed separator in which most of the water is removed and run to the sewer, while the oil is collected, filtered and reused.

The heating system for the buildings is operated on about 4 lb. pressure, in order to supply a distant building. When sufficient exhaust steam is not available from the units which are in service connections are made so live steam can be supplied. The condensation returned from the system is pumped to the feed-water heater by either of two Worthington volete pumps, with a capacity of 125 fal. a minute, which are in a sump in one corner of the engine room basement. Each of these pumps is direct-connected by a vertical shaft to 3-h.-p. vertical induction motor.

The boiler room contains a 20-ton exhaust-steam-absorption Carbondale ammonia refrigerating machine for cooling the drinking water supplied to the works. This machine has a capacity for cooling 600 gal. of water an hour from 80° Fahr. to 40° Fahr. A duplex Dean steam pump, with a capacity of 3,000 gal. an hour, circulates the cooled water through a piping system extending to the various buildings of the works.

Two fire pumps, one a cross-compound Underwriters machine, with a capacity of 1,000 gal. a minute, and the other a simplex Blake, with a capacity of 1,600 gal. a minute, are placed in the basement of the boiler room. These pumps draw water from the river and are connected to a private fire-protection system of the works. The buildings of the works are equipped throughout with automatic sprinkler system supplied from the fire-protection lines, which are normally under pressure from the city mains. The connection between the latter and the fire protection system is provided with a check valve which closes when the fire pressure from the station is turned on the system.


Traveler Dismantied for Use in Painting and Riveting, Las Vacas Viaduct.

Water for flushing toilet fixtures in the different buildings is supplied from tanks carried by the roof trusses of the building. A 4-in. Worthington centrifugal pump, direct-connected to a 15-h.p. induction motor, is placed in the basement of the engine room and pumps river water to these tanks. This unit operates at 1,200 r.p.m. and was formerly installed in the old plant where it operated satisfactorily for three years at this relatively high speed.

Lubricating oil is supplied to the various units in the plant by a gravity-feed distributing system. A supply tank for cylinder oil and one for engine oil are suspended in the roof trusses. Two small duplex pumps raise the oil to these supply tanks from two storage tanks in the basement. The cylinders of all steam-consuming units are supplied with oil through a special form of oil atomizer which was designed and patented by Mr. W. L. Parker, chief engineer for the company. This atomizer is simply a short piece of threaded pipe of the same size as the tap for the regular oil inlet in the steam supply line to the unit. The opening of the pipe is contracted toward the end, inside the steam line, and terminates on a flat surface which forms the top of a rectangular projection with three sides widened out below this surface by steps, as shown in an accompanying illustration. The opening from the pipe on this surface is placed so the latter is against the direction of steam flow, with the result that the steam drives the oil in a fine spray from the bottom steps of the three sides of the small rectangle.

These atomizers were first used in the original plant of the works, in which they produced excellent results and are being used in the new plant with equal satisfaction. They have also been used to relieve troublesome cylinder lubrication conditions in a number of power plants in Elgin and vicinity.

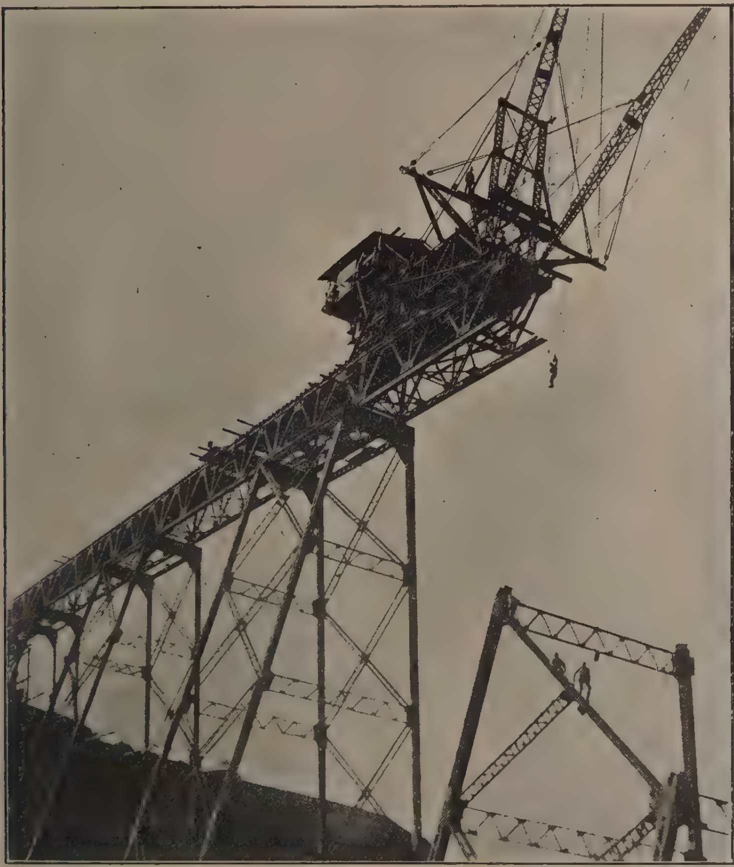
The oil drips from the various units in the station are returned to two Turner oil filters in the basement of the engine room. These filters are over two storage tanks, one for cylinder and the other for engine oil, from which the oils are raised to the supply tanks under the roof.

Mr. Geo. E. Hunter is general superintendent and Mr. W. L. Parker is chief engineer for the Elgin National Watch Co. Mr. J. W. Lyons, of Chicago, was retained as consulting engineer for the company during the design and construction of the plant.

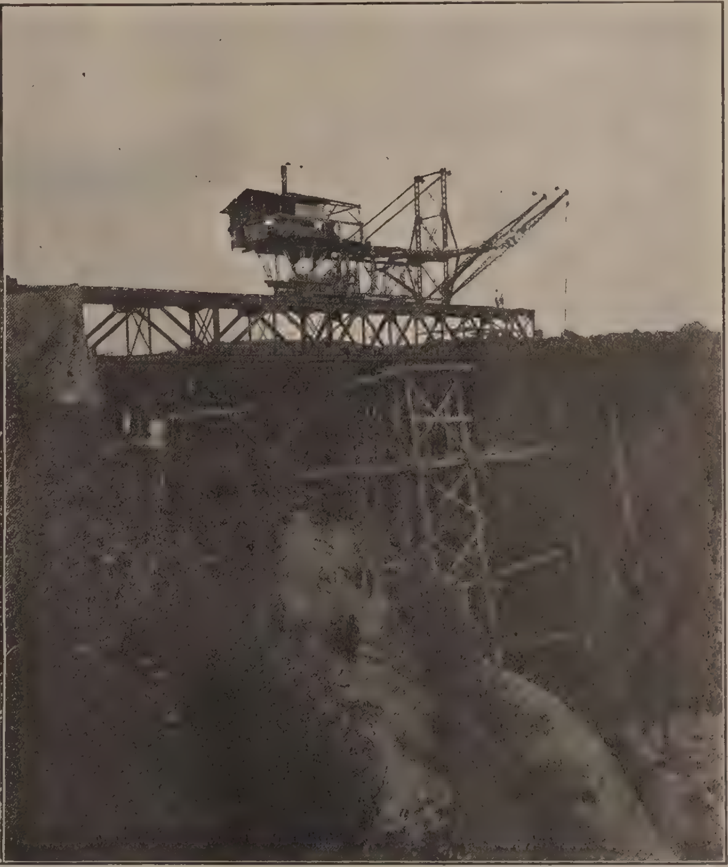
An Interesting Competitive Test of marine engines will be made when the three scout cruisers, now under construction for the United States Navy Department at Quincy, Mass., are in the water. These ships are of identical dimensions, the only difference being that one of them will be equipped with the Parsons turbine, another with the Curtis turbine, and the third with ordinary reciprocating engines. It is purposed to have a triple trial of these vessels, taking them to sea at the same time, subjecting them to the same exactions, and observing the relative merits of the different types of motive power. It is expected that the trial will take place late in the Summer of 1908, by which time the ships should be completed. This will be the first opportunity American naval experts have had to examine closely the practical operation of turbines as applied to naval uses.

The Erection of the Las Vacas Viaduct.

The narrow gauge single track Las Vacas Viaduct of the Guatemala Ry. is 743 ft. long and 229 ft. high and has seven 30 and 40-ft. towers, supporting one 55-ft. span and seven 75-ft. spans. The towers are each made with two vertical bents having a maximum of seven stories and have X-braces in all faces and horizontal struts in the transverse planes only. The tops of the bents have transverse box girders about 4 ft. deep and 18 ft. long which weigh about 3,500 lb. each and have the column flanges field riveted between their webs. Each span is made with a pair of lattice girders 12 ft. deep and 10 ft. apart on centers with the usual top and bottom laterals and transverse sway bracing. The lower flanges of the trusses are seated on the box girders. The 30-ft. and the 75-ft. spans weigh about 26,000 and 50,000 lb. respectively and the maximum tower weight is about 25,000 lb., the total weight of the viaduct being nearly 1,000 tons. The towers have a maximum width of about 87 ft. at the base where one column of each bent has an expansion bearing. Excepting some suspension rods supporting the longest members and diagonals in the horizontal planes through the bases of the towers all members of the viaduct are riveted and all were shipped separately and assembled in erection. The details of the design were described in The Engineering Record of Jan. 26, 1907.



Erecting Section of a Tower Bent.



Erecting First Tower from Falsework.

The location of the viaduct is remote and rather inaccessible, supplies and skilled labor are difficult to secure, no machine tools or steelworks are available within a great distance, many weeks are required to receive erection plant or materials from the bridge shop and communication with headquarters in New York is difficult and costly so that it was imperative that the erection plan should be fully developed before construction was begun and that all plans and materials should be at the site for the beginning of operations. It was determined to erect the viaduct by the cantilever method with an overhead derrick traveler and plans for it were prepared and the operations outlined as illustrated in The Engineering Record of February 2, 1907.

The 35,000 lb. steel traveler was designed for service in the erection of other viaducts now under construction for the same R. R., and consisted essentially of a pair of riveted trusses about 53 ft. long, 10 ft. deep and 10 ft. apart on centers connected by transverse and lateral bracing in the planes of the top chord only and mounted on four wheels. The forward vertical end posts were continued 23 ft. above the top chords and braced together transversely to form masts for a pair of 60 ft. tapered steel booms 30 in. square at the center. Each boom was rigged with a 4-part topping lift and a 5-part hoisting tackle of 6,500 lb. capacity. A wooden boom 20 ft. long was also provided between the steel booms. Swinging tackles were attached to the extremities of a long horizontal transverse beam fastened to the deck in the rear of the mast and the traveler was anchorred to the finished viaduct when in service. Materials were delivered at grade at the first end of the viaduct and are run through the traveler underneath the top lateral bracing. The hoisting engine and boiler were carried on an extension at the rear ends of the top chords of the traveler trusses and served to counter-balance ordinary loads on the derrick booms.

It was proposed to assemble the traveler at grade on the ground just beyond the first abutment of the viaduct and in that position to erect with it the first bent of the first tower and the first span. The traveler was then to advance partly on the first span and complete the erection of the tower and the tower span, the latter being temporarily connected by top chord links and bottom chord blocks to the first span so as to transmit temporary erection stresses when they were used as anchorages for the succeeding span. For this service the trusses were to be temporarily reinforced by wooden vertical posts to carry the vertical shear over the tower bents.

The traveler was to advance to the front of the tower and erect a wooden falsework tower about 50 ft. high to receive the 2nd panel point of the first 75-ft span. After the span was erected up to the tower it was to be connected for reaction stresses to the forward end of span 2 and the traveler moved forward on it to complete its erection and erect the 2nd tower. When this span was completed its forward end was to be jacked up from the 2nd tower releasing the connections between the rear end of the span and span 2 and the traveler advanced to complete the remainder of fthe viaduct in the same manner. The travelers were designed by Mr. H. D. Bush, and the method of erection and the other details of plant were developed by Mr. A. W. Buel.

When the work was executed some of the conditions encountered varied slightly from what had been anticipated and the erection although conducted closely on the lines above described was modified somewhat to suit the cirumstances and to secure the greatest total expedition and economy. The principal modifications consisted in the omission of the wooden boom, the operation of the swinging lines by hand tackles, the erection of the trusses in sections, bracing them transversely by bolted wooden outriggers, the movement of the entire traveler back and forth to carry pieces forward instead of raising and lowering the booms, and the modification of the traveler to serve for a moveable riveting and painting scaffold after the erection of the steel work was completed. All of these changes were made with a careful recognition of the existing conditions and were fully justified by the successful issue of the work. The cautious handling of assembled sections of the trusses as single units and the method of carrying them forward and connecting them proved simple and convenient and suggests similar methods of operation in designing future cantilever erection of small riveted trusses, a class of work which has been very seldom attempted by the cantilever methods. The erection methods are well described in the following letter from Mr. W. D. Penny, contractor.

"I consider the traveler the finest machine for viaduct work I have ever used. The booms worked admirably in the heaviest wind, and it blew very hard twenty-five per cent. of the time. The tackles to swing the booms were 10-in. blocks rove with 1 1-4-in. manilla lines; there were times I wished they were larger. Each line was run individually to a hand winch, these winches being bolted to the sides of the traveler just above the sills and easily reached from the track. The reasons that these lines were not led to the winches of the donkey were to avoid the confusion of too many lines being operated at once and to avoid the tying of lines at winch heads as much as possible, but the chief reason was that the winches were worked by native labor and a considerable saving in money was effected. One man at each winch could easily and safely in the heaviest wind swing the booms with a heavy post suspended from each. I never put in the center boom. I could see no benefit to be obtained from the use of it.

I never cantilevered the entire length of any cantilever spans, for the following reasons. First, it would have made the box girder a diffficult and slow connection in a very inaccessible place. Second, I was afraid I could not get sufficient guys on the end of the span and did not like to run the traveler out so in the heavy winds. So I adopted the following plan in erecting the cantilevers.

"I backed the traveler up till I had sufficient room to connect together one side section of first portion of the cantilever. This I put together, laying it down under the booms, firmly bolting and drifting it together and connecting all lateral plates, etc. It was then picked up by both tackles, one attached to the bottom chord and one to the top chord and properly balanced. The traveler was then run ahead to a proper connecting distance and firmly clamped down. The section was never raised over a foot from the track while being run out, so when the tackle on the bottom chord was slacked off the section hung almost in the connecting position, it only being necessary to slack it down about a foot. The cantilever links were then connected and the section slacked off. The operation of picking up, carrying out and connecting the section never occupied over a half an hour. . To move the traveler with the section suspended to it, all I ever used was a 1¼-in. runner on each side.

"In erecting the towers I raised one section on the side nearest to the traveler, then moved out as far as possible on the center section of the span and out hauled the difference with a runner from the donkey. This operation was continued until the third section from the top was reached; then one side of the tower was run up to the top, the box girder put on and the bottom chords of the span connected. The rest was easy.

"In running up one side of the tower, the tower braces were connected to the third section down. This left only two sections without bracing, and even with the box girder on, before the bottom chords were connected, there was very little sway motion. To back up, raise the box girder with both boom tackles, run out and connect it, generally occupied twenty minutes. It was the easiest connection we had. I never telegraphed ahead anything but light members. I found it quicker and safer to back the traveler up and run ahead with the load, it could be moved so easily.

"To wind-brace the cantilever, I bolted a 12x12-inx30-ft. piece across the end of the first section of the span, then bolted 3x12-inx30-in. pieces from the end of the timber both ways to the span. There never was any motion to speak of. The booms were very seldom raised or lowered, and never with a load. We avoided the raising of the booms by moving the traveler, In erecting the first 75-ft. span, I avoided counterbalancing and cantilevering by running the near side of the tower to the top at once, bracing it at some of the sections to the timber tower.

"The only casualty of any kind during erection was the death of one native, who in passing fuel from the deck of the viaduct to the donkey engine on the traveler, carelessly fell between the ties. This happened on the highest part of the structure. He had a clear fall to the ground, and was, of course, instantly killed.

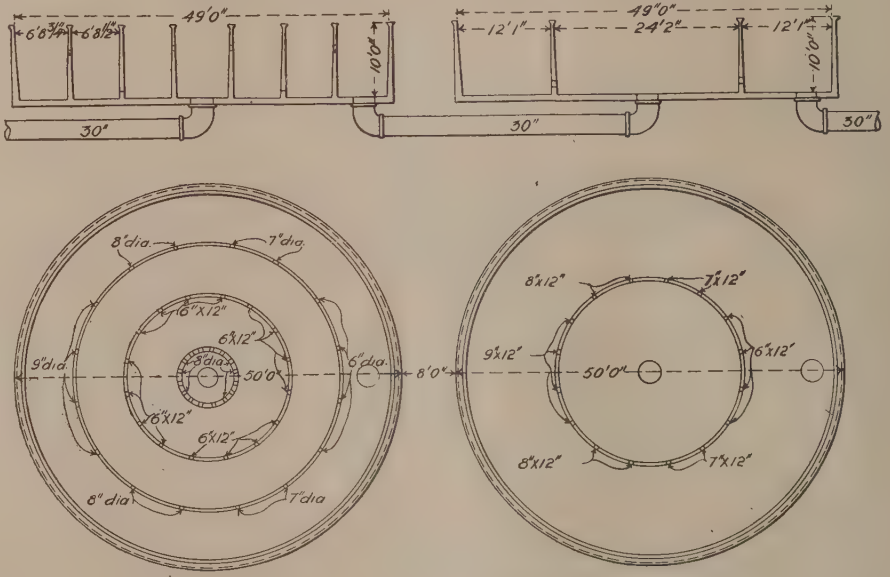
"Although the erection is finished, I have the traveler still in commission, using it to rivet and paint from. I have taken off the booms and high end bent, removed the hoisting engine and the deck, putting false caps 5 ft. above the original deck to give head room for locomotives. I have scaffolds 4 ft. wide and 45 ft. long suspended by 10-in. blocks and 1¼-in. lines hung on each side of tower. Each scaffold carries two gangs with their tools, including forges. The scaffolds are started at the top and lowered as the riveting and painting proceed. When tower is completed to the ground, they are hoisted to the top and the operation repeated."

The viaduct was designed by Mr. V. G. Bogue, New York, Mr. W. H. Kennedy and Mr. A. W. Buel, associated engineers on railways and bridges respectively; Mr. S. F. Shaw is chief engineer and Mr. J. H. Pope bridge engineer of the railway company. The steelwork was fabricated by the Baltimore Bridge Co. Mr. H. D. Bush, vice president and manager, and was erected by Mr. W. T. Penny.

A 150-Ton Wharf Crane has just been completed at the works of Messrs. Armstrong, Whitworth & Co., Elswick, Eng., for placing heavy machinery in erected form, in vessels alongside the wharf. It is mounted on a steel pedestal above the wharf, so as to turn in a complete circle, and has a lifting range of 100 ft. It is hydraulically operated, having two gears of 75 tons capacity each, and an auxiliary lifting gear of 25 tons capacity which has a range of 117 ft.

The Circular Tanks at the Lancaster Filtration Plant.

The water supply of Lancaster, Pa., is drawn from the Conestoga River, a stream subject to frequent and sudden floods, at which times the water carries much loam, clay and vegetable detritus. This supply is purified by a 9,000,000-gal. filtration plant which has been in operation about a year and a half and which consists of a water softening or coagulating system, a series of preliminary filters and a series of final slow-sand filters. There are fifteen preliminary filters, each 6x16x35 ft., and fifteen slow-sand filters, each 6x16x140 ft. The preliminary and the slow-sand filters are of the Maignen type and are very much like those of the 4,000,000-gal. South Bethlehem plant, described in detail in The Engineering Record of July 15, 1905. The tanks into which the water first enters after the coagulant is added, however, where it is agitated and settled and receives preliminary scrubbing are unusual in design and operation. They are designed to remove the bulk of the mud and coagulant before the water reaches the preliminary filters.

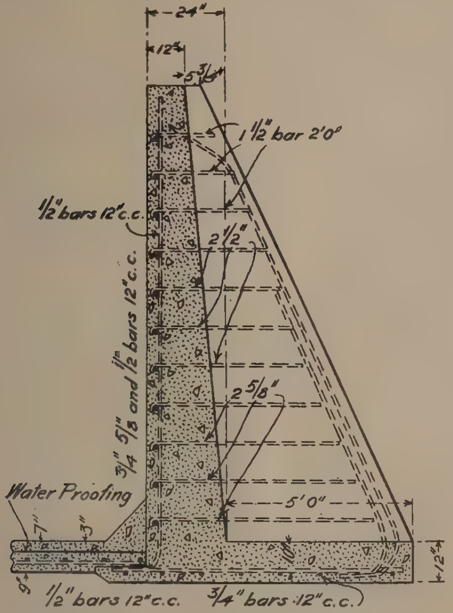


Plan and Section of Tanks at Lancaster Filtration Plant.

At first the reagents used at Lancaster were mainly lime and soda but, as it was considered desirable not to change the chemical character of the water, sulphate of alumina and soda carbonate are now used. These neutralize each other and simply form a coagulating precipitate without making the water harder or softer and without leaving anything objectionable in it. The reagents are added as a dry powder which is thrown into the water by a distributing device actuated by a Poncelot undershot water-wheel operated by the water as it flows into the coagulating basin.

From the coagulating basin the water passes first into a circular agitating tank, 49 ft. in diameter and 10 ft. deep, entering the tank through a vertical 30-in. pipe in the center of the bottom. The tank has three circular concentric baffle walls placed as shown in accompanying illustrations. The first or inner baffle is provided with a series of 8-in. round openings about 6⅓ ft. above the tank bottom through which the chemically-charged water passes into the second section of the tank; the second baffle has openings at the bottom, 6 in. wide and 12 in. deep; and the third has 6 to 9 in. round openings 6 ft. above the bottom; the water leaves at the bottom of the fourth section through a 30-in. pipe that leads to the center of the next tank. The openings in the baffle walls are calibrated so that the flow through each wall is equally distributed about its circumference as nearly as possible. By the time the water reaches the outlet pipe it has been thoroughly agitated and all the activity of the chemicals as a coagulant has been expended.

The second tank, also 49 ft. in diameter and 10 ft. deep, is provided with a single circular baffle wall with rectangular openings, 12 in. deep and 6 to 9 in. wide, arranged so as to distribute the flow evenly. In this tank the velocity is low and most of the coagulated material, which appears as coarse particles, settles to the bottom while the clarified water passes out through a 30-in. pipe in the bottom of the outside section of the tank and on into two 49x10-ft. tanks without baffle walls. These tanks are preliminary scrubbers and the water is divided equally between them. It enters at the bottom and, being distributed over the floor by suitable concrete drain-tiles, rises through layers of cobble stones, coarse coke and sponge and passes off at the top. By the time the water has reached the surface of these rough scrubbers it is clear enough to be admitted directly to the regular Maignen preliminary filters even during the worst flood periods. There is plenty of room in the coarse material of the rough scrubbers for large deposits of mud and all the circular tanks can go a long time without cleaning. When they are to be cleaned it is done by flushing and shoveling during periods when the river water is clear enough to go direct to the filter plant proper without passing through the coagulating system.

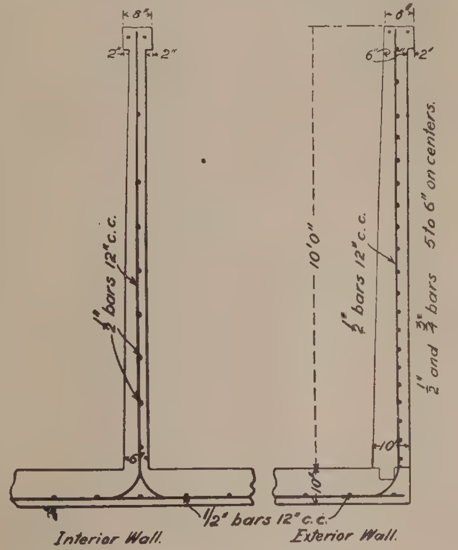


Section of Wall of Pure Water Basin.

The soil in which these tanks are built is a good loamy clay resting on bastard limestone rock. The excavation was made in original soil. There is now about 5 ft. of earth about the walls.

The circular tanks are made of a mixture of crusher-run limestone, ¾ in. being the maximum size, and Dragon Portland cement in proportions equivalent to 1:3:5, reinforced with New Style corrugated Johnson bars for which the unit working tensile stress assumed was 12,500 lb. Each bottom slab is 10 in. thick and is reinforced with two series of ½-in. bars on 12-in. centers, 2 in. of the slab being below the reinforcement. The outer walls are 6 and 10 in. thick at the top and bottom, respectively. They are reinforced with ½-in. vertical bars 12 in. on centers, placed as shown in an accompanying section and bent into the floor slab about 18 in., and with circumferential bars, ½ in. to ¾ in., spaced 5 to 9 in. on centers as shown. The baffle walls have ½-in. vertical rods on 16¾ and 19¾ in. centers and ½ in. circumferential rods on 18-in. centers. The openings in the baffle walls were made to come between the rods of both series and the openings for the 30-in. pipes in the floor slabs are surrounded by a flanged metal ring into which the floor slab rods are hooked.

In constructing each tank the floor slab rods were first put in place and wired at their intersections; then the vertical wall rods were put in place and the floor concrete was laid. The vertical rods for the outer walls were held in place during the placing of the floor concrete by attachments to the framework for the lagging. Holding in place the vertical rods of the baffle walls was more difficult but it was managed by wiring the rods together and running guy wires to the outer wall forms and to the pipe hole in the center of the floor slab. The floor was laid at one time, a joint recess being provided for the outer wall as shown on the section. No special joint was made for the baffle walls as it was not necessary that these be watertight. When the floor concrete had set enough to hold the vertical wall rods in place the circumferential rods were wired to them, the forms being built up and the concrete poured at the same time. The concrete was very wet and dense and though a Sylvester wash was to have been used it was found to be unnecessary as the tanks were watertight when the forms were removed. The circular framing for the walls was made at a planing mill in 8-ft. sections and ⅞-in. dressed lumber was used for lagging. The surface of the concrete was not treated in any way after the forms were taken down.



Sections of Circular Tank Walls.

Coagulating and Softening Tanks, Lancaster Filtration Plant.

The pure water basin is also built of reinforced concrete. It is 100x200 ft. and 12 ft. deep, giving a capacity of 1,500,000 gal. The dimensions of the walls, floor slab and counterforts and the arrangement of the reinforcement is shown in an accompanying illustration. The counterforts are placed 12 ft. on centers.

The Lancaster plant was built by the Pennsylvania Maignen Filtration Co. according to designs prepared by Mr. P. A. Maignen, and has a guaranteed bacteriological efficiency of 97 per cent., a requirement that has been more than fulfilled in regular performance. Mr. W. H. Boardman was chief engineer for the filtration company and Mr. F. H. Shaw acted as consulting engineer for the city. The designs for the reinforced concrete tanks and pure water basin were prepared by Messrs. Webb & Gibson, reinforced concrete specialists, Philadelphia. Messrs. Harmer & Quinn, Philadelphia, were the general contractors, Mr. Chas. Doebler, superintendent of construction.

Canal Transportation in France.

The following report, covering the cooperation of State and communities in the construction of French canals, the cost of constructing them, and the comparative freight charges by canals, rivers, and railways, is furnished by Consul-General Robert P. Skinner, of Marseille:

The systematic effort to improve and facilitate river navigation in France took the form, in 1879, of a general law in regard to railroads, rivers, canals, and seaports. It was rightly considered that these were all branches of the same subject and that there should be a scheme of general improvement harmonizing in every detail. The law of 1879 was, in fact, merely a programme, intended to be executed as the resources of the country might permit, and up to 1890 it had been departed from only to the extent made necessary by the progress in methods of transportation. One of the essential features of the Freycinet programme of 1879 was the standardizing of various types of canals which had been brought into existence through local pressure. M. Freycinet proposed a canal type permitting the utilization of barges 126.31 ft. long by 16.40 ft. beam and drawing 5.9 ft. of water.

Among other projects contemplated in this scheme was the cutting of a canal from the Rhône River at a point near Arles to the city of Marseille, thus shortening the distance between this city and Lyon and making it possible to utilize barges and other craft, which can not with safety navigate in the Mediterranean Sea. The project for this canal has been recast a number of times, and actual work has been commenced only recently. The canal will be 50.33 miles in length, will have a channel 9.84 ft. deep, and will accommodate barges of 2,000 tons burden. The cost has been fixed at $13,703,000, of which the State is to pay $6,851,000, the town and department councils $2,605,500, and the Marseille chamber of commerce $4,246,000. When this canal was first proposed the Rhone was navigated by steamboats, most of which have been replaced by barges moving in fleets.

Where the French policy of canal, port, and river improvement differs strikingly from that prevailing in the United States is in the matter of original expense. While such works in France are invariably controlled by the State, it is recognized as a fixed rule that the localities through which waterways pass or where ports are created profit to a degree which can not be enjoyed by the community at large, and that these localities should contribute an appropriate part of the primary investment.

In discussing the details of work to be first taken up the Senate committee thus expressed itself: "Priority should be given to enterprises which, while urgently demanded, have also the advantage of an assured financial co-operation amounting to 50 per cent. at least."

The chambers of commerce are usually the instruments through which municipalities contribute, and the obligations so created are usually met by the issuance of bonds, the interest and sinking fund thereof being provided for by the collection of authorized fees, the chamber of commerce being frequently an administrative body. The Marseille chamber of commerce will collect a toll of 2 cents per package upon imported merchandise in barrels, boxes and sacks, and per ton upon merchandise in bulk, as a means of discharging its financial obligation in respect to the Rhone Canal, and it is already collecting fees and rentals with the proceeds of which it maintains certain wharves in a high state of efficiency, for the use of shipping of every nationality.

The length and cost of the French transportation system up to Jan. 1, 1901, were as follows:

Description.	Length in Miles.	Paid by Interested Localities.	Paid by the State.	Total Cost.
Local highways	316,898	$227,740,000	$81,060,000	$308,800,000
National highways	23,656	....	303,975,000	303,975,000
Tramways	2,628	126,608,000	....	126,608,000
Local railroads	2,971	88,587,000	2,509,000	91,096,000
Trunk railroads	23,784	1,920,736,000	834,532,000	2,755,268,000
Rivers and canals	7,397	6,755,000	322,503,000	329,258,000
Ports	....	25,669,000	174,858,000	200,527,000
Total	377,334	$2,396,095,000	$1,719,437,000	$4,115,532,000

The freight embarked on canal and river boats for the past four years was as follows:

	1903. Tons.	1904. Tons.	1905. Tons.	1906. Tons.
Canals	18,513,471	18,195,000	18,657,806	18,357,339
Rivers	14,617,471	14,243,701	15,119,534	15,381,963

Freight rates by canal are materially lower than rates upon the same merchandise by rail, but the difference is less striking perhaps than an American investigator might expect. On March 23, 1907, the comparative rates per ton from Cette to Toulouse and Bordeaux were as follows:

Articles.	Cette to Toulouse. Rail.	Cette to Toulouse. Canal.	Cette to Bordeaux. Rail.	Cette to Bordeaux. Canal.
Wine	$1.33	$1.16	$2.02	$1.64
Wheat	1.33	1.06	2.02	1.73
Oil	3.38	1.16	4.90	1.73
Petroleum	1.33	1.21	2.02	2.02
Phosphates	1.43	1.16	2.39	1.93
Coal	1.84	.77	2.87	1.45
Tiles	1.96	1.16	2.99	1.93

Nearly the entire freight traffic on the Rhone River is controlled by one company, which enjoys a practical monopoly thereof, but there appears to be no reason why other companies, if equipped with the necessary capital and provided with an efficient fleet, might not enter the field. Although shipments by river to Marseille are transported a much greater distance than shipments forwarded by rail, on account of the absence of the connecting canal now being constructed between Marseille and Arles, river freight rates are nevertheless considerably lower than those quoted by the railway company. The following sample scale of prices prevailed on March 26, 1907, upon the two routes, Marseille to Lyons:

Article.	Water. Per Ton.	Rail. Per Ton.
Soap	$2.07	$2.89
Vegetable oil	2.99	4.24
Wine in casks	2.70	3.38
Petroleum	2.70	3.86
Coal	1.54	2.41
Wheat	1.93	2.63

Between Marseille and Lyons canal and river tonnage is always available for any amount of freight that may be offered. The business is not very remunerative on account of the strong competition of the railroad company.

As to whether it would pay to build the French canal system now, had it not been called into being before the existing railways were constructed, can be answered in the affirmative. It is very unlikely that various cities, notably Marseille, would be clamoring at this time for the right to spend their own money upon improved waterways, if they were not convinced of their practical utility. While the French railway system, with the exception of some comparatively unimportant lines, is the result of private enterprise backed by government guarantees, according to the French theory of political economy they belong to the state, and ultimately will be brought under state ownership, as they are already under state control. It is considered that the railways and canals both have their particular function in the modern state, and that the proper equipment for economic development is incomplete without both. Referring to the results already obtained in France from an imperfectly developed system of waterways, the Senate committee said in 1903:

"It is important that we achieve the concordance of the dimensions of intercommunicating canals, and that we select for first execution the waterways yet to be constructed which appear to be of the greatest necessity. It is impossible to deny that traction itself is less costly by water than by rail. The interested localities have the right to demand the connection of existing railways and canals, where such connections would be favorable to the trade of regions not in direct contact with the canals. In nations where canals and railways are in the hands of the state, this has been accomplished already. . . . Where transportation by water and rail are both available, they complement and complete each other, the one transporting heavy materials, the low cost of which is an indispensable condition to the vitality of industries which aliment in their turn the traffic of the railway lines."

A New Type of Current Insulator for high-tension transmission lines was suggested by Mr. H. W. Buck at the recent meeting of the American Institute of Electrical Engineers, which bids fair to materially change present methods of line construction. It consists of a simple form of unreinforced strain insulator with wide flaring petticoats, which are linked in series to support the line wires by a swinging suspension at each pole. At intervals of about every 10 poles, the line is anchored in either direction by the strain links similarly arranged. It is claimed that but 10 towers or poles need be used per mile with this construction, and that the voltage carried is limited only by the number of insulators inserted in the links, only four of the insulators in series being needed for a 100,000-volt line.

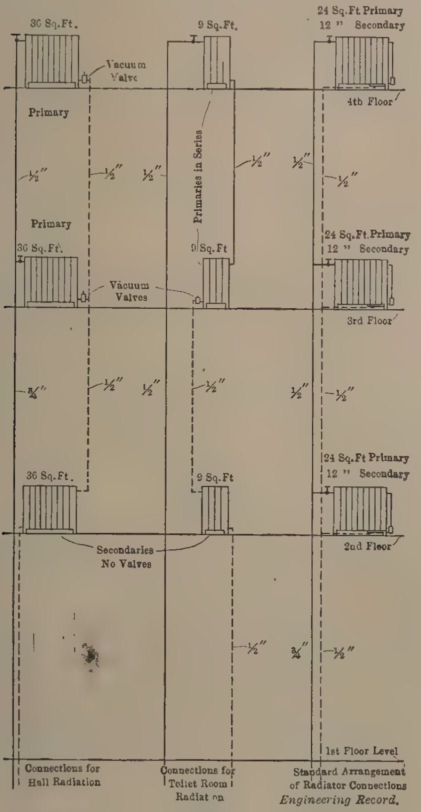
The Vacuum Heating System in the Godfrey Block, Grand Rapids.

A vacuum steam heating system has recently been installed in the Godfrey Block at Grand Rapids, Mich., which is a departure from the usual arrangement of connections and radiation for vacuum heating. The building is a four-story and basement brick structure having a north and western exposure. It is 27x110 ft. in plan and is occupied by stores on the lower floor and offices on the upper three floors. It has an unusually large amount of window glass exposure, rendering it difficult to heat, and was recently refitted with a low-pressure two-pipe steam heating system having a total of 2,500 sq. ft. of radiation for the entire building, which has a novel system of return connections.

The requirements of the building for heating were for about 400 sq. ft. of radiation on each of the three upper floors, 750 sq. ft. on the first floor and 186 sq. ft. in the basement, in addition to the exposed mains. The distribution of heating surface on the three upper floors is such that there are ten units on each floor, while that upon the main floor consists of nine comparatively large units, arranged so that by supplying five of the first-floor radiators from the basement ceiling main, the upper floor equipment could be supplied from seven riser lines. These risers, as installed, carry from 96 to 386 sq. ft. of radiation each, and are of only ¾ to 1¼-in. pipe, whereas, as ordinarily figured, these amounts would have required 1½ and 2-in. sizes. The return risers are similarly of ½ and ¾-in. pipe, owing to the use of the vacuum system. The supply risers receive steam through a basement main connected to the boiler through a 1½x3-in. reducing valve. This main divides into a 1-in. line supplying a ½ and 1-in. riser at the rear and a 2½-in. main extending around the front side of the basement ceiling and supplying the remaining risers and radiator connections. The return system consists of a vacuum main on the ceiling and ranges in size from a ½-in. line at the extreme end to a 1¼-in. line at the return pump.

The selection of this particular range of pipe sizes is the result of the adoption of the Simonds compound vacuum system, which makes use of the heat carried in the return condensation in special radiation. Secondary radiators are so connected with the vacuum valves of the main radiators that the considerable amount of heat carried in the water of condensation after having passed through each main radiator and its vacuum valve is utilized before it enters the return mains. The water of condensation discharged from radiators in the ordinary low-pressure steam heating system ranges from 208° to 210° Fahr., and difficulty is often experienced with re-evaporation when this heated water passes through the discharge valve into the vacuum of the return line. This difficulty is here utilized by the installation of the secondary radiator units, the steam from the boilers being fed through the usual distribution system to the main radiators while the secondary sections receive the water of condensation which the main sections discharge through the regular vacuum valves. These secondary radiators are in all cases installed in capacities about one-half of those of the main or primary radiator units, it being figured that the heated water passing into the vacuum of the return lines will re-evaporate to a greater or less extent so that the secondary radiation will be of actual value as heating surface. This is borne out in actual experience, the condensation passing from the secondary radiation to the vacuum pump as solid water and no difficulty being experienced with re-evaporation in the return lines, with consequent necessity of injecting cold water into the pump suction to condense vapor carried through and permit effective operation of the pump.

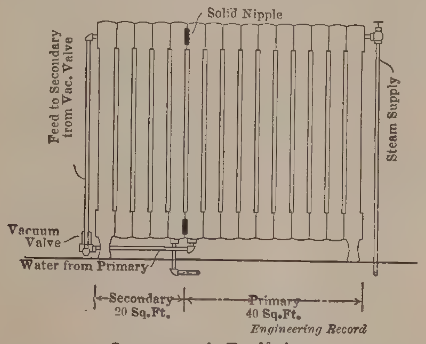
The radiation in the Godfrey Building is, for the greater part, installed on the usual compounded plan, with both primary and secondary sections in close proximity, although there has also been incorporated in this installation an unusual arrangement of primary and secondary radiation separated on different floors. This is carried out in the hall and toilet-room radiation, each of which groups has two primary radiators located on the third and fourth floor levels, which discharge their condensation through a single secondary radiator on the second floor level, the only difference from the regular arrangement of units being that the secondary radiation is on a lower level to which the water of condensation flows freely. In the case of the hall radiation, there is a 36 sq. ft. radiator on both the third and fourth floors to which steam is delivered directly from the riser lines, each delivering through its regular vacuum valve to a ½-in. return line carried down to the secondary radiator of the second floor level; this return line feeds vapor and water of condensation to the secondary radiator, which is also a 36-sq. ft. unit and thus serves as an effective heating surface equal in capacity to that of the hall radiators above, except for the slightly reduced temperature due to the vacuum of the return system. In the case of the toilet-room units, a somewhat different arrangement was made. Here a 9-sq. ft. radiator is installed in the toilet on each floor, but steam is supplied to them by a ½-in. riser leading to the unit on the fourth floor only. This top floor unit has no vacuum valve, but the return connection is connected directly to the steam inlet of the similar unit on the third floor, and this unit has the regular vacuum valve to serve both units, which discharges the water of condensation and vapor to the second floor unit, as in the preceding case.



Engineering Record.

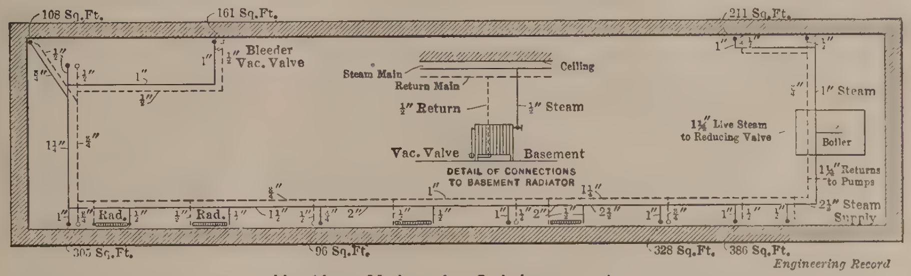
Details of Radiator Connections.

In the radiation installed in the various offices, the original arrangement of using separate radiator units for primary and secondary radiation has been dispensed with and compound radiator units installed. These consist of cast-iron sectional radiator units of the usual type, except that one-third of the columns on the return end are isolated from the other two-thirds on the inlet end by solid nipples at top and bottom connections, both sides having inlet connections at the top of the outside columns and return connections at the bottom of the inside columns next to the solid nipple. The arrangement of connections is, as shown in the accompanying detail sketch, for steam supply to the top of the outside column of the primary or inlet end, and return connections from the base of the inside column of this primary end to the vacuum valve which in turn discharges its condensation into the top of the outside column of the return or secondary section. In this section, the condensation vaporizes under the vacuum and effects additional heating surface, after which the water of condensation passes freely to the vacuum return system without encountering further valves or obstructions. This renders the radiators compact, and no difference in appearance from the ordinary units. There is, it is stated, no difficulty experienced in raising the water of condensation from the vacuum valve up to the inlet end of the return side of the radiator units, as it is found that the condensation after passing the vacuum valve into the vacuum of the return line vaporizes partly if not wholly, merely condensing in the secondary section of the radiator to water before entering the return lines. In fact, no difficulty is said to be experienced in lifting the condensation considerable distances, as in the basement radiators the return lines are located on the ceiling and condensation is easily raised from the secondary unit to this level, a rise of about 9 ft.



Engineering Record

Compound Radiator.



Engineering Record

Heating Mains in Sub-basement.

Steam is supplied to the building by an Atlas internal-fired horizontal shell boiler of the marine type with internal furnace. It is a self-contained unit and is set without brick work, the shell being encased with asbestos block covering. It is of 40 h.-p. rating, being planned for sufficient capacity to operate the heating system on the ordinary method with gravity returns and also another building adjoining. It operates at 20 to 30 lbs. pressure and delivers to the heating mains through a pressure-reducing valve which lowers the pressure to about atmospheric, this being varied from 1-lb. pressure to 4 in. vacuum, according to the heating service required. The vacuum pump is a 4½x5x8-in. Burnham simplex pump which delivers from the return mains to a receiving tank, and from here the condensation is returned to the boiler by a simplex feed pump of similar make which has 3x2x3-in. cylinders.

The results that have been obtained from this system have been very satisfactory, the heating service having proved adequate in all parts of the building. The system as now installed was operated with a fuel consumption of 72 tons of mine run of soft coal for the heating season of 1905-6, while last winter but 69 tons were used. The small sizes of mains for steam supply and return contribute largely, it is thought, to the economy of the system, but, of course, the principle factor of saving lies in the reduction in the secondary radiation of the temperature of the condensation returns to a point where the injection of cold water into the vacuum pump suction, with consequent heat waste, is not necessary for proper operation of the pump. The system was designed and installed by the Simonds Heating & Specialty Co., Detroit, Mich., who control this system of vacuum heating.

Electric Locomotives of the Pennsylvania Railroad.

With a view to determining the type best adapted to pulling its heavy passenger trains through the New York tunnels, the Pennsylvania R. R. has in progress a series of experiments upon electric locomotives. Through the experiments on the West Jersey and Seashore division and the Long Island R. R., the company hopes to determine the general characteristics of the electric locomotive and to secure operating data based on actual service. Of the two direct-current locomotives now undergoing tests, one is equipped with four 350-h.-p. geared motors, and the other with four gearless motors. The gearless locomotive has one of its trucks equipped with two 320-h.-p. motors supported by springs from the main journals and independent of the truck frame, while the other truck has two 300-h.-p. motors rigidly fastened to the frame. In exterior appearance the two locomotives are almost identical. The trucks are of the four-wheel type, having frames placed outside the wheels, with pedestal boxes and adjustable wedges similar to those used in locomotive practice. On account of their short wheel base, the trucks have a tendency to tilt in operation, and thereby shift a portion of the effective load from one pair of wheels to the other. By an ingenious automatic switching mechanism the power delivered by the motor on the heavily loaded axle is increased and the power delivered by the motor on the lightly loaded axle diminished, in proportion to the difference in axle loads. By this expedient the pulling power of the locomotive is increased 25 per cent. The driving wheels are 56 in. in diameter. The cab is entirely of metal. The control mechanism is in duplicate and placed in diagonally opposite corners of the cab. The locomotives are equipped with hand, straight air, automatic and high-speed brakes. The weight of the geared locomotives is 174,100 lb. while that of the gearless locomotive is 195,000.

Book Notes.

A useful summary of some instructive experiments conducted under the direction of the Engineering Experiment Station of the University of Illinois has recently been published by it under the title of "Effect of Scale on the Transmission of Heat Through Locomotive Boiler Tubes." For a great many years it has been generally held that scale 1-16 in. thick required an expenditure of 15 per cent. more fuel to accomplish the same results as clean tubes, and doubling the thickness of the scale doubled the resistance to heat transfer. The experiments described in this pamphlet give materially different results. Some of them were made on a locomotive equipped at first with scaled and then with clean tubes and others on individual tubes procured from railways running through the Central States. They show that the loss in heat transmission with scale up to ⅛ in. thick varies between insignificant amounts to 12 per cent., and depends more on the mechanical structure of the scale than its thickness.

A book useful as a detailed account of the development of public health regulations in the British metropolis is "The Sanitary Evolution of London," by Henry Jephson, of the London County Council. It describes in the first chapter the sanitary measures taken prior to 1855, and gives quotations from reliable publications regarding the frightful state of filth in which a large part of the population were forced to live. It then takes up the progress made in each subsequent decade, explaining how the peculiar municipal subdivision of the district acted as a steady obstacle to progress until means for overcoming it were found. There were public commissions for paving, Mr. Jephson states, others for street improvements, others for lighting, and others even for bridges across the river. All in all, several hundred such commissions had been created without any relation one to the other, and without any central controlling authority, by as many acts of Parliament. They were mostly self-elected or elected for life or both, and were wholly irresponsible to the taxpayers, or to anyone else, nor were their proceedings in any way open to the public. Many of them had large staffs of well-paid officials and there were perpetual conflicts of jurisdiction between them and an absolute lack of anything approaching municipal administration. The development of sanitary improvements from such a condition of divided authority is traced in much detail in this book, and in many places the author's comments on measures and conditions are decidedly interesting, although all readers will not agree with his views. The book is one of those valuable reviews of engineering progress that are all too rarely written because of the great labor involved in collecting and compiling the data. (Brooklyn, 203 Fulton St., A. Wessels Co., $1.80).

One of the most interesting pamphlets relating to street improvements that has appeared in a long time is the "Specifications for Street Roadway Pavements," by Mr. Samuel Whinery. The author believes that in the present state of the art it is entirely practicable to frame specifications for paving materials and methods so that the engineer and municipality may safely assume responsibility for the quality of the work produced. It is his opinion that a contractor who negligently or purposely violates specifications during construction is unlikely to be more faithful or scrupulous in living up to any guarantees he may make with regard to the future, even where the terms and conditions of such guarantees may be clearly defined and indisputable. When his specifications are viewed in this light they are distinctly good, and subject only to the single general criticism of being so detailed that many engineers will probably prefer to abridge them for actual use. In respect to the details, there are a number of points with which The Engineeing Record does not agree. It does not believe, for instance, that the contractor should be required to deliver cement for pavement foundations on the work at least ten working days before it is to be used, as the author suggests, for it is just as well at times to keep it in the cars or warehouse until actually needed, for it can be inspected there as easily as in a storage shed on the street. As regards the proposed requirements for asphalt there are details which seem unnecessarily severe and the necessity of specifying anything but the asphaltic cement is certainly open to question. In this respect the new Kansas City specifications will be preferred by many engineers, since their requirements are confined to the asphaltic cement, the material actually used. If the specifications go into the detail suggested by the author they must only be used by someone in close touch with the progress of asphalt technology, and even then the requirements will be open to criticism. For example, the author states that crude asphalt must be refined at a temperature not exceeding 450° Fahr., and material which does not distinctly soften at 185° will not be accepted. As a matter of fact some useful bitumens are injured at 450° and some of the best show no distinct signs of softening at 185°. Again, the section on refined asphalts excludes some of the Cuban asphalts which can be handled satisfactorily with an asphaltic flux. In this section there is also a clause relating to a test of asphalts in water which seems extremely severe in view of the showing made in actual service by asphalts which this clause would reject. In the section relating to flux, the requirement of a specific gravity of less than 0.958 would exclude admirable fluxes with an asphaltic base having a specific gravity of 0.96 to 0.99. In the section on asphaltic cement, there is a requirement regarding viscosity which would throw out material made from California residual pitch and might cause the rejection of good material made from Cuban and Trinidad asphalts. These are a few of the features of the asphalt pavement specifications which are open to criticism and similar comments might be made on the suggested specifications for asphalt blocks, granite and brick. They are pointed out to show the well-defined differences of opinion that exist regarding details of paving lest the reader should regard the specifications, good as they are as a whole, as beyond criticism in detail. (New York, Engineering News Publishing Co., 50 cents).

Letters to the Editor.

The Cause of the Quebec Bridge Failure.

Sir:—I understand that no allowance was made for secondary stresses in the design of the Quebec bridge, and also that the connection joining the lower chord members of the anchor and cantilever arms was rigid. This does not allow the adjoining chords to take their proper position, while the deflection takes place, without developing considerable bending stress in the chords. I would not be surprised to find the secondary stresses caused by this bending to run up as high as 50 or 100 per cent. of the direct chord stress and so might largely have contributed to the failure. I would therefore suggest checking the truss strain sheets for secondary stresses in the chords.

I have had much experience with secondary stresses in bridge members and have found them in some cases of great importance, and therefore would never neglect them unless the trusses were designed to minimize them. Rigid connections between anchor and cantilever lower chords have been used in other important bridges where they have given much anxiety, and I am convinced that they should always be eliminated and a connection designed with both members free to adjust themselves independently on the pin center. In the case of the Quebec bridge the effect of the secondary stresses is greater on account of the great depth of the trusses, and the corresponding considerable deflections of the first and second panel points from the main pier on both sides, tending to produce contraflexure, which, in webs of the depth there existing, develops enormous stresses to augment the primary stresses. This effect becomes less farther from the pier and, beyond the feet of the first diagonals, is not transmitted to the first two subpanels of lower chord. The V-shape member used in the Quebec bridge is, moreover, very difficult to build in the shops, very difficult to check and verify after construction and quite liable to inaccuracies in the angle and bearings, and in exact dimensions, any of which might concentrate the excess load on a very small area until the latter yielded enough to distribute the stress.

Bridge Engineer.

Unit Spiral Tables.

Sir: I have examined with much pleasure the table and explanatory matter for Talbot's Spiral in your issue of Sept. 7, and feel certain that all field men who use this easement curve will find it a great help. As stated in the article the unit table is partially developed in the printed editions of this spiral, and the advantages pointed out, but Mr. Kyle's table is much more extensive. The great advantage, to my mind, of a unit table lies in the fact that it embodies under one series of headings all of the quantities necessary for running the curve, while all other tabulated spirals that I have seen have from a dozen to thirty distinct tables, each one of which is applicable to a certain chord length, though sometimes, also, to the multiples of that length. This advantage was briefly mentioned in your article, but, in my opinion, should be emphasized. There is but one table to turn to and never any danger of taking values that apply to a different set of conditions, a cause for frequently re-running spirals.

Though not thoroughly conversant with the mathematics of many spirals I believe that a unit table like the one you have presented is possible only with a spiral such as Talbot's, in which the chord length can be varied from point to point along a given curve, in the same fashion as a circular curve can be run by setting intermediate points wherever desired.

It must have occurred to many of your readers that the table as set up in the regular edition of The Engineering Record is in rather cumbersome shape for field use, and I hope that you have decided to reprint it, together with the explanatory matter, in handy form. It would do much toward placing in the hands of field men one of the most conveniently arranged tables I have seen.

Very truly yours,

Chicago, Ill. N. E. A.

A Uniform Retardation Brake Gear is in use on the North-Eastern Ry. in England. It consists of an inclined slot mechanism applied to the brake shoes so that, as the grip on the wheels increases, owing to the greater coefficient of friction at decreased speeds, the shoes are drawn away slightly and the pressure relieved somewhat. It is said that the device prevents gripping and skidding. With plain gears the braking pressures are kept well below the weight carried on the wheels, but with this gear they are increased to 160 per cent. of that due to weight and then are reduced automatically as the train stops.

CURRENT NEWS SUPPLEMENT

SEPTEMBER 14, 1907.

DIRECTORY OF NATIONAL TECHNICAL AND TRADE SOCIETIES.

American Society of Civil Engineers. Secretary, Charles Warren Hunt, 220 West 57th St., New York.

American Society of Mechanical Engineers. Secretary, Calvin W. Rice, 29 West 39th St., New York.

American Institute of Electrical Engineers. Secretary, Ralph W. Pope, 29 West 39th St., New York.

American Institute of Mining Engineers. Secretary, R. W. Raymond, 29 West 39th St., New York.

National Fire Protection Association. Secretary, W. H. Merrill, Jr., Chicago.

American Institute of Architects. Secretary, Glenn Brown, Washington, D. C.

Association of Engineering Societies. Secretary, Frederick Brooks, 31 Milk St., Boston, Mass.

American Society of Heating and Ventilating Engineers. Secretary, W. M. Mackay, 113 Beekman St., New York.

Canadian Society of Civil Engineers. Secretary, Clement H. McLeod, 877 Dorchester St., Montreal.

Society for the Promotion of Engineering Education. Secretary, Prof. M. S. Ketchum, University of Colorado, Boulder, Colo.

American Society for Testing Materials. Secretary, Prof. Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

American Society of Municipal Improvements. Secretary, George W. Tillson, 831 Ocean Ave., Brooklyn, N. Y. Annual meeting, Detroit, Mich., Oct. 1-4, 1907.

Association of Railway Superintendents of Bridges and Buildings. Secretary, S. F. Patterson, Concord, N. H. Annual convention, Milwaukee, Wis., Oct. 15-17, 1907.

American Railway Engineering and Maintenance of Way Association. Secretary, E. H. Fritch, 962 Monadnock Block, Chicago.

American Water Works Association. Secretary, J. M. Diven, Charleston, S. C.

American Street and Interurban Railway Association. Secretary, Bernard V. Swenson, 29 West 39th St., New York.

American Foundrymen's Association. Secretary, Richard Moldenke, P. O. Box 432, New York.

Engine Builders' Association of the United States. Secretary, J. L. Lyle, 39 Cortlandt St., New York.

American Public Works Association. Secretary, W. H. Flint, Chattanooga.

Association of American Portland Cement Manufacturers. President, J. B. Lober, 1232 Land Title Building, Philadelphia.

National Association of Cement Users. President, Richard L. Humphrey, Harrison Building, Philadelphia.

American Society of Refrigerating Engineers. Secretary, H. W. Ross, Room 806, 258 Broadway, New York.

American Public Health Association. Secretary, Dr. C. O. Probst, Columbus, O. Annual meeting, Atlantic City, Sept. 30-Oct. 4, 1907.

PERSONAL NOTES.

Mr. E. H. Rondall has been elected city surveyor of Fredericksburg, Va.

Mr. J. A. Smith has been appointed general manager of the Panama R. R., succeeding Mr. W. G. Bierd.

Mr. Harry T. Poe, Jr., has resigned as assistant engineer with the American Pipe Mfg. Co., to become city engineer of Americus, Ga.

Charles R. Long, for many years president of the Louisville Water Co., Louisville, Ky., died at his home in that city, Sept. 4, aged 67 years.

Prof. D. W. Mead read a paper on hydraulic engineering at the University of Wisconsin, at the first regular fall meeting of Western Society of Engineers, in Chicago, Sept. 4.

Richard J. McGrann, a well-known railroad contractor, died recently at his home in Lancaster, Pa., aged 70 years. He was a cousin of Bernard J. McGrann, of Newark, N. J., also a railroad contractor, who died recently.

Lieut.-Col. Frederic V. Abbott, Corps of Engineers, U. S. A., assistant to the chief of engineers, has been ordered to the Philippine Islands for duty in connection with the construction of fortifications in Manila and Subig bays.

The tenth annual convention of the Central States Water-Works Association will be held in Wheeling, W. Va., Sept. 17, 18 and 19. The Windsor Hotel will be headquarters. Mr. Wm. Allen Veach, Newark, Ohio, is secretary of the association.

Messrs. Lockwood, Greene & Co., architects and engineers, Boston, Mass., were the engineers for the manufacturing buildings recently built for Messrs. Jas. Pyle & Sons, at Shadyside, N. J., and for the power plant for the same firm, described in The Engineering Record, Aug. 31. Mr. Chapman is engineer in charge of the power plant.

Messrs. J. G. Ellendt and O. L. Griffith have severed their connection with the Concrete Engineering & Supply Co., New York City, and together with Mr. C. E. Tirrell, have organized the J. G. Ellendt Co., with offices at 1 Madison Ave., New York. They will engage in consulting engineering and contracting on reinforced concrete work.

Mr. Horace Ropes, formerly connected with the Metropolitan Water Board of Boston and the New York City Board of Water Supply, has been engaged by the New York State Water Supply Commission to assist Mr. John R. Freeman, whose appointment as director of the engineering forces of Water Supply Commission was noted recently in these columns.

M. Jules Vacherot, whose work as chief landscape architect at the Paris Exposition of 1900 won for him the decoration of the Legion of Honor from France and decorations from several other European countries, arrived in New York recently. M. Vacherot, who is now in charge of all the gardens of Paris, recently became associated with a New York firm of landscape architects and engineers. He will spend two months of each year in New York.

Messrs. Willis G. Tucker, professor of chemistry and toxicology in the Albany Medical College; Olin H. Landreth, professor of engineering in Union College, and James H. Stoller, professor of biology in Union College, have established the Albany Sanitary Bureau, Albany, N. Y., for the purpose of conducting a practice in sanitary investigation, examinations, inspections and reports. Special consideration will be given such problems as public and private water supplies, stream pollution, sewerage conditions in municipalities and institutions, sanitary conditions in schools, churches, hotels and other public buildings, and the examinations of dairies and creameries. Prof. Landreth is secretary of the company.

Mr. Julian C. Smith, recently general superintendent of construction for Dodge & Day, engineers and constructors, of Philadelphia, has resigned his position with that firm and has acquired a controlling interest in the Atlantic Engineering & Construction Corporation, of Norfolk, Va. This company, the name of which will be changed to The Atlantic Co., Inc., will do a general engineering and contracting business throughout the southern seaboard States. The company now has on hand contracts for the grading for the large new terminal yards of the Tidewater Ry. Co., at Sewell's Point, Va., and for the construction and equipment of a hydro-electric power plant at Boonton, N. J.

A commission appointed by the Prussian Government is making a tour of this country studying heavy electric traction systems preparatory to taking up the electrification of Berlin steam suburban lines, including the Stadtbahn, a connecting line extending through the city, and the Ringbahn, a belt line around the city. The chairman of the commission is Herr Geheimer Baurat Wittfeld, of the Ministry of Railways, Highways and Bridges. Associated with Mr. Wittfeld and accompanying him on the trip are: Dr. Ing. Walter Reichel, of the Berlin Polytechnic University, and formerly chief engineer of the railway department of the Siemens & Halske Co.; Mr. Frederick Jordan, general manager of the Felten Guilleume-Lahmeyer works of Frankfurt; Mr. Emmerich Frischmuth, engineering director of the Siemens-Schuckert Works, of Berlin, and Mr. Phillip Pforr, manager and chief engineer of the railway department of the General Electric Co., of Berlin. The commission has visited the installations of the New York Central, New York, New Haven & Hartford, and Long Island railways; the Erie electrification at Rochester, the Boston subway and elevated systems; the works of the General Electric Co., at Schnectady, and plants at Niagara Falls, Pittsburg, Indianapolis and Fort Wayne, Chicago, Helena and Spokane are also included in the itinerary. The cost of the installation contemplated is estimated at about $20,000,000.

BUSINESS NOTES.

The Aberthaw Construction Co. have closed a contract for building a concrete-steel dam 40 ft. high and about 225 ft. long for The Barker Mills, Auburn, Me., under license from the Ambursen Hydraulic Construction Co., of Boston. Mr. I. W. Jones, of Milton, N. H., is the engineer for the company.

Judge Buffington, of the U. S. Circuit Court of Appeals, has rendered a decision in the suit of the Lidgerwood Mfg. Co., against the Lambert Hoisting Engine Co., holding that the latter has infringed the North patent for one-quarter and three-quarter speed cableways, owned by the Lidgerwood company.

The contracting office of the Virginia Bridge and Iron Co., heretofore located at Little Rock, Ark., has been transferred to New Orleans, La. The office will be in charge of Mr. F. E. Golian, who was connected with the engineering department of the company for some time, but has recently been with the Atlanta office.

The Bellevue Pipe & Foundry Co. during the past summer cooled their foundry by forcing air over pipes through which cold water was circulated. The molding room was kept at a good working temperature and not a single day was lost on account of the heat. The cooling equipment was installed by the American Blower Co., Detroit.

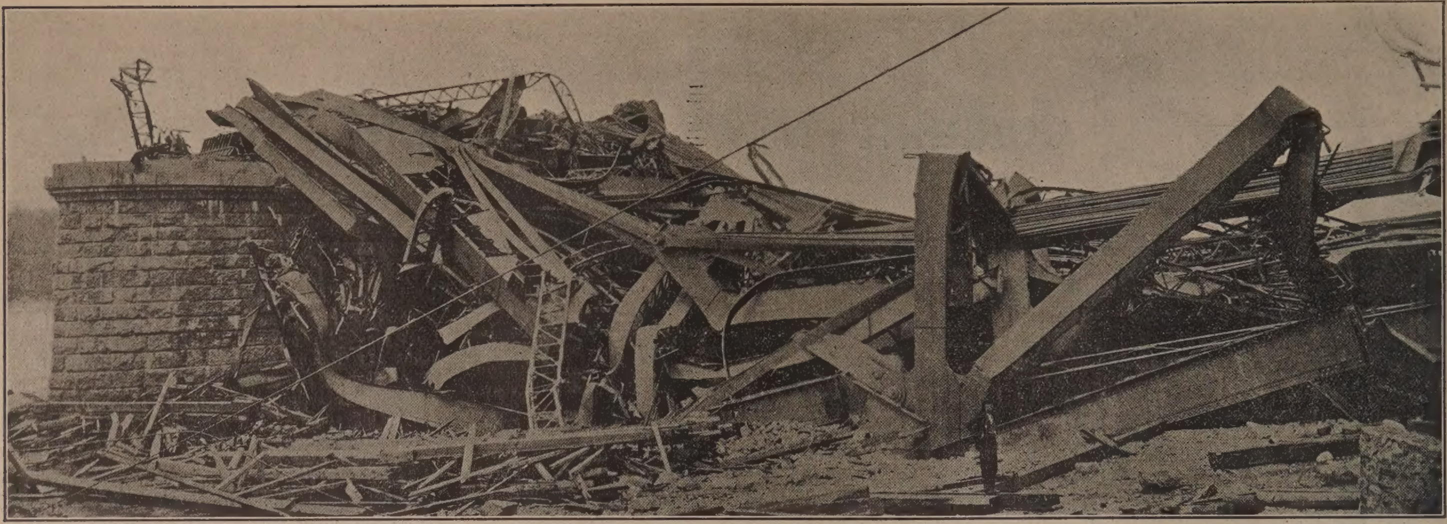
Dodge & Day, engineers and contractors, Philadelphia, have submitted a betterment report covering the entire factory of Fayette R. Plumb, Inc., of Frankford, Pa., and are now engaged in making extensive alterations to the forge shops. When this work is finished other departments will be taken up and ultimately the entire plant will be remodelled.

The Pacific Coast headquarters of the Standard Underground Cable Co., which have been at Oakland since the earthquake, are now permanently loacted at 511-514 Shreve Building, San Francisco, Cal., the office continuing in charge of Mr. A. B. Saurman as Pacific Coast manager. The new Oakland factory of the company is about four times the size of the one destroyed by fire after the earthquake, is fireproof and equipped with the latest machinery. A warehouse for the products of the company's eastern factories is maintained at Oakland.

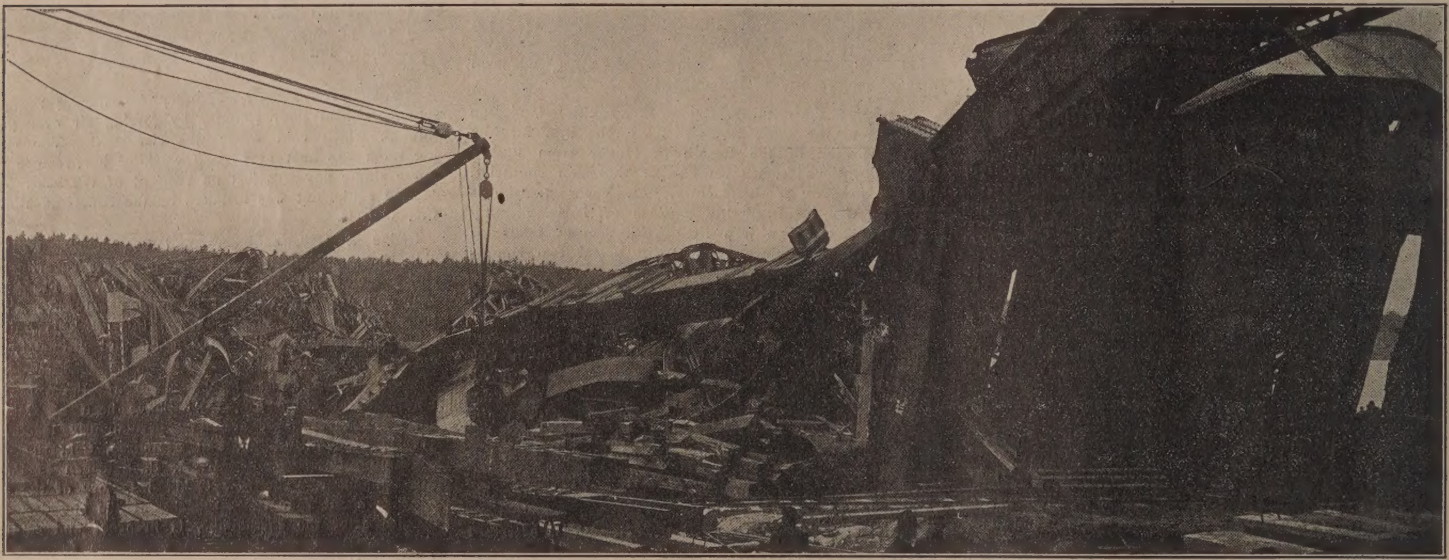
On Aug. 22 the new Hunt St. factory of the D. T. Williams Valve Co., Cincinnati, was completely destroyed by fire, and all of the tools and machinery of the lubricating department, the only department which had been moved to the new building, were lost. The patterns, however, were still at the Broadway plant. A new lubricating department is now being installed on East 8th St., and castings and tools are being manufactured as quickly as possible, so that deliveries of lubricating devices can be made about Oct. 15. None of the other departments were injured.

A mechanical stoker of unusual design has recently been brought out by the Sarco Fuel Saving & Engineering Co. A reciprocating ram delivers a definite amount of coal in front of a pendulous shovel, the edge of which swings near the bottom of a pan. The shovel is drawn back mechanically against a strong helical spring until released, when it is pushed forward by the spring and shoves the coal forward on the grate. The force of this push is varied automatically at each swing of the shovel in order to distribute the fuel properly. One shovel will stoke a furnace width of about 3 ft. These stokers are now in use at several paper mills.

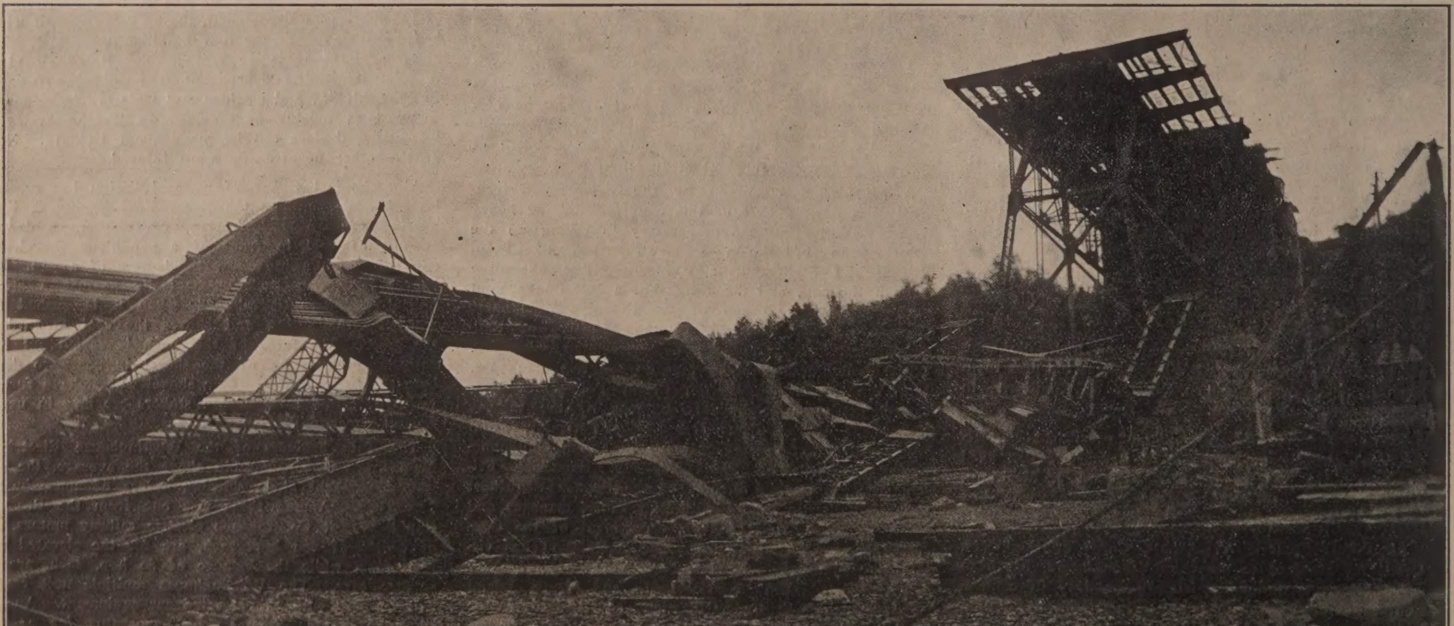
The July business of the Westinghouse Electric & Mfg. Co. was considerably above the average, the railway department alone showing orders of approximately $2,500,000. Among these was one from the Brooklyn Rapid Transit Co. for 400 electric railway motors, 200 of which, of 200 h.-p. each, are for the elevated railroad cars, while the balance of 60 h.-p. each, are for surface cars. The Westinghouse multiple unit control will be used with the elevated car equipment. Another large order, for the electrical apparatus for 24 substations, consisting of static and rotary transformers, and switch-boards, was received from the Schoepf interests, of Cincinnati, which operate extensive urban and interurban electric railways in Ohio and southern Indiana.



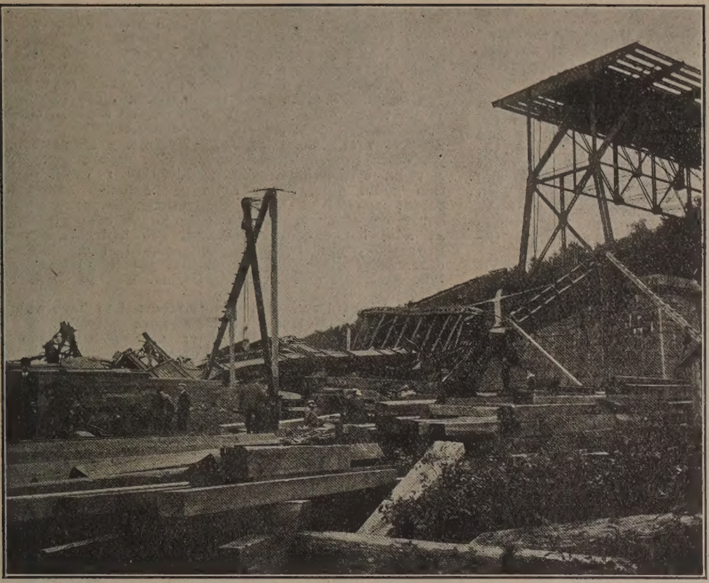
THE WRECKAGE AT THE MAIN PIER FROM THE WEST.



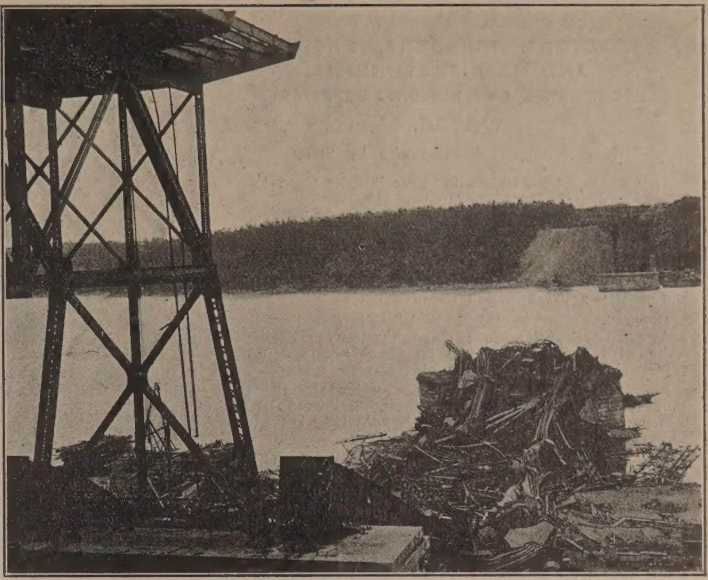
THE REMAINS OF THE SOUTH ANCHOR ARM.



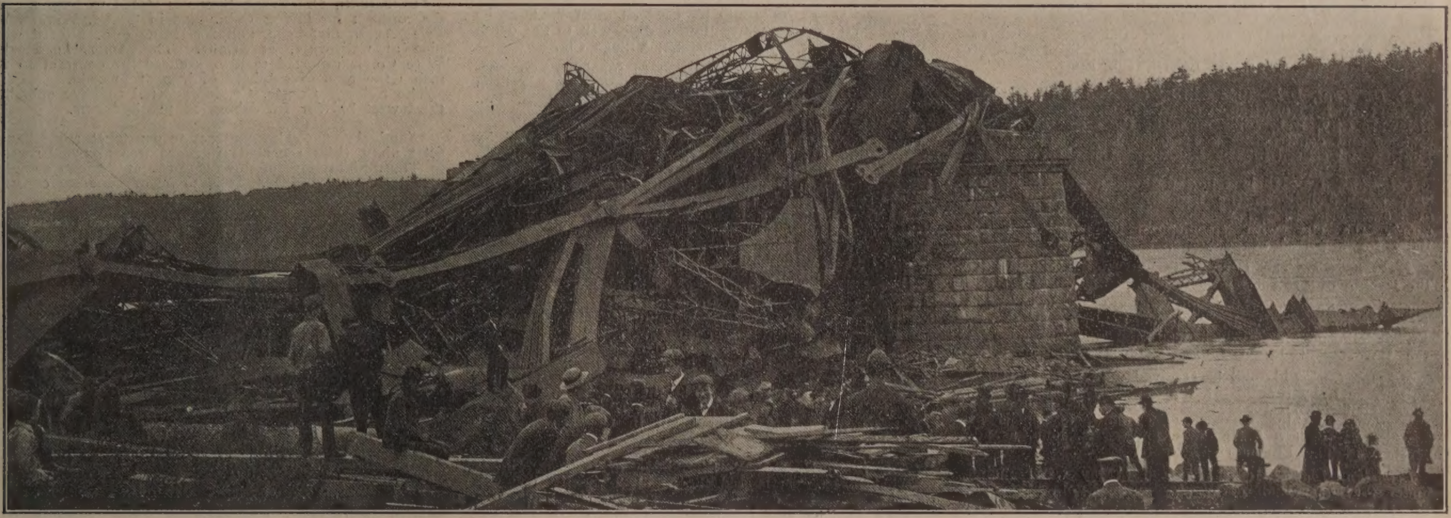
VIEW OF ANCHOR ARM WRECKAGE, QUEBEC BRIDGE, FROM THE NORTHWEST.



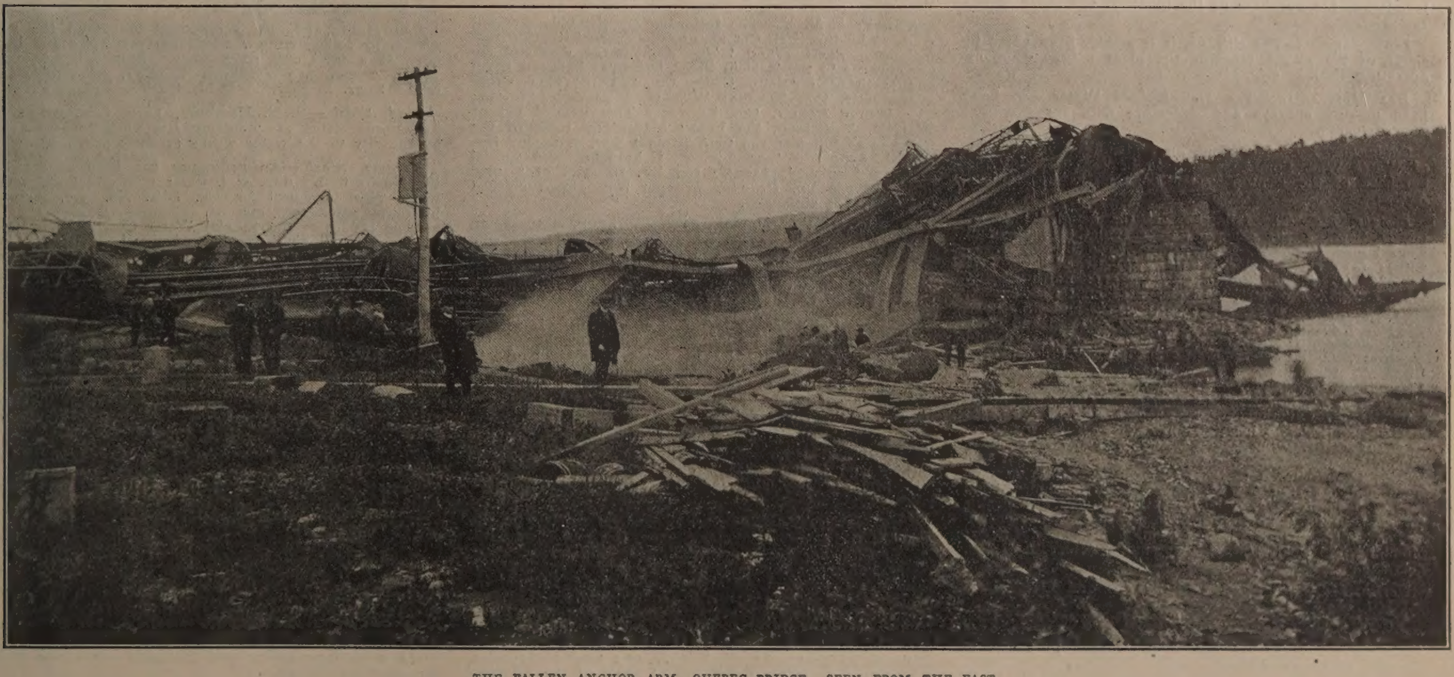
THE FALLEN ANCHOR BENT.



VIEW LOOKING NORTH.



THE WRECKAGE OF THE MAIN PIER FROM THE EAST.



THE FALLEN ANCHOR ARM, QUEBEC BRIDGE, SEEN FROM THE EAST.

CONTRACTING NEWS

OF SPECIAL INTEREST TO
CONTRACTORS, BUILDERS, ENGINEERS AND MANUFACTURERS
ENGINEERING AND BUILDING SUPPLIES

WATER.

Notes Arranged Alphabetically by States.

Ft. Morgan, Ala.—Bids will be received by Capt. Louis F. Gabbard, Jr., Box 605, Mobile, Ala., until Sept. 25, for the construction at Ft. Morgan, Ala., of a 150,000-gal. tank and trestle and for pumping plant, ice machine and cold storage.

Van Buren, Ark.—J. E. Power and others, according to reports, have purchased the plant of the Van Buren Water Co. and will improve the same.

Oakland, Cal.—The Bd. Pub. Wks. is stated to have adopted a resolution to petition the City Council to unite with San Francisco in trying to secure a water supply for Oakland from the Sierra Nevada Mountains.

Los Angeles, Cal.—Bids will be received by the Bd. Pub. Wks. Oct. 7 (W. R. Ormsby, Acting Pur. Agt.) for cement-making machinery for the Los Angeles Aqueduct, as per specification No. 6.

Hotchkiss, Colo.—The Alta Vista Reservoir Co. (C. A. Fowler, Pres.) contemplates work costing about $25,000. The work will be done by day labor, the bulk of the work by hydraulic power. Length of dam 1,000 ft. outlet pipe, 15-in. cement. Capacity 45,000,000 ft. Fred. G. Hotchkiss, Engr., Hotchkiss.

Paonia, Colo.—The Mt. Lamborn Canal & Reservoir Co. contemplates building 7 miles of canal this fall and a reservoir and 6 miles of canal in 1908. Probable cost, $75,000. E. P. Martin, Paonia, Engr.; C. C. Hawkins, Secy.

Wilmington, Del.—Bids will be received Sept. 30 by the Water Dept. for the construction of covered slow sand filters, consisting of 6 beds and a covered filtered water reservoir with a capacity of 10,000,000 gals., together with appurtenances, as advertised in The Engineering Record. Theo. A. Leisen, Ch. Engr.

Ft. Du Pont, Del.—Bids will be received until Oct. 10 by Capt. J. L. Knowlton, Constr. Q. M., Ft. Du Pont, Delaware City, Del., for remodeling the sewer and water systems and constructing a 150,000-gal. tank at Ft. Du Pont, as advertised in The Engineering Record.

Columbus, Ga.—It is reported that an agreement has been reached between the Hudson Eng. & Contr. Co., of New York, N. Y., whereby the company agrees to supply the city with 5,000,000 gals. artesian water daily for a period of 20 years.

Jackson, Ga.—The Council is said to be considering the issuing of $10,000 bonds to extend the water system.

Catoosa Springs, Ga.—Bids will be received until Sept. 21 by Capt. E. D. Anderson, Q. M., U. S. A., Ft. Oglethorpe, for a deep well and water system at the Government target range, Catoosa Springs.

Atlanta, Ga.—Bids will be received until Oct. 23 (readvertisement), by the Bd. of Water Comrs. (Park Woodward, Gen. Mgr.), for furnishing and erecting complete a sectional washing pressure filter plant, to consist of 8 units, ea. unit 8 ft. in diam. and 20 ft. long, as advertised in The Engineering Record.

Lewiston, Idaho.—It is proposed to lay water mains under the supervision of W. A. Smith, Supt., at a cost of $57,300. An election is to be held Sept. 21 to vote on this question. John E. Nickerson, Compt.

Lindsay, Ind. Ter.—It is reported that $25,000 bonds have been voted for a water supply.

Tulsa, Ind. Ter.—The Council is reported to be contemplating the purchase of the plant of the water works company.

Indianola, Ia.—The citizens, it is stated, have voted in favor of the city purchasing the plant of the company operating in this city.

Des Moines, Ia.—The Des Moines Water Co. have been making surveys and collecting data for proposed improvements.

Covington, Ky.—The Com. on Water Wks. of the Bd. of Water Wks. Comrs. is said to be contemplating the purchase of the Kenton Water Co.'s mains in Madison Ave.

Bangor, Me.—The following are the detailed bids received Sept. 4 for constructing coagulating basin and head house (Geo. W. Fuller, Engr., 170 Bway., N. Y. City): (*a*) C. N. Taylor, $46,195, (*b*) Greer Filter Co., $47,786, (*c*) P. B. Elkins Co., $49,511: Earth excav., 6,200 cu. yd., *a* 50 cts., *b* 50 cts., *c* 55 cts.; rock excav., 20 cu. yd., *a* $3, *b* $4, *c* $5; earth embk. and fill., 4,700 cu. yd., *a* 40 cts., *b* 30 cts., *c* 30 cts.; top soil and seeding 15,000 sq. ft., *a* 4 cts., *b* 1 ct., *c* 6 cts.; road and walkways, 60 cu. yd., *a* $5, *b* 2.50, *c* $2.50; concrete, Class A, 170 cu. yd., *a* $9, *b* $15, *c* $13; concrete, Class B, 2,180 cu. yd., *a* $8, *b* $9.25, *c* $10. steel rods, 58,000 lbs., *a* 3.25 cts., *b* 4.9 cts., *c* 5.5 cts.; head house superstructure, lump sum, *a* $5,800, *b* $5,037, *c* $5,255; electric lighting and heating, lump sum, *a* $950, *b* $1,000, *c* $810; self-cleaning screens and appurtenances, lump sum, *a* $2,200, *b* $1,400, *c* $1,970; c. i. pipe, specials and valves, lump sum, *a* $4,750, *b* $5,540, *c* $5,440; sewers, lump sum, *a* $1,100, *b* $737, *c* $739; brick manholes, lump sum, *a* $400, *b* $275, *c* $65; manhole covers and drains for coag. basin, lump sum, *a* $300, *b* $200, *c* $400; coagulant devices, lump sum, *a* $2,500, *b* $1,800, *c* $1,587; plumbing and small piping, lump sum, *a* $1,400, *b* $1,350, *c* $1,235.

Berlin, Md.—See "Power Plants, Gas and Electricity."

**Grosse Pointe Farms, Mich.*—J. G. Armstrong, Clk., writes that the contract to lay 2¾ miles of water pipe (bids opened Aug. 31) has been awarded to Cornelius Cronin, of Grosse Pointe.

**Hibbing, Minn.*—The Village Council is stated to have accepted the bid of the Prescott Steam Pump Co., of Milwaukee, Wis., to furnish a steam pump at $7,500; two other bids were received, one from the Worthington Steam Pump Co., at $9,300, and the other from the Fairbanks Morse Co., at $6,791.

Kansas City, Mo.—D. E. Cornell, Mayor of the West Side, is said to be considering the calling of an election to vote on the issuing of bonds to construct a new water plant.

Ft. Keogh, Mont.—E. C. Bebb, a government irrigation expert, is reported to have examined the portion of the Ft. Keogh reservation which corners on the Tongue and Yellowstone Rivers, ascertaining the area that could be irrigated and the required elevation of the head gate of a ditch which would irrigate the flat. Between 7,000 and 10,000 acres were found to be within the domain of such a ditch and an elevation of 8 feet above the bank of the Yellowstone, at a point 5 miles west of the post, where the bluffs border the river, would be sufficient to give the necessary fall.

**Sanders, Mont.*—J. R. Thompson, Secy. Sanders Co-operative Ditch Co., writes that the contract to construct an irrigation ditch (bids for which were received Aug. 31) has been awarded to J. C. Lyndes, of Sanders, at from 15 to 35 cts. per cu. yd., as per classification; in all about $32,000.

Billings, Mont.—The purchasing of the plant of the Billings Water Co. by the city is being agitated.

**Bradshaw, Neb.*—C. B. Palmer, Jr., Village Clk., writes that the contract to construct water works (bids opened Aug. 30) has been awarded to the Drake-Williams Mount Co. and Crane Co., of Omaha, Neb.

Fremont, Neb.—See "Power Plants, Gas and Electricity."

Harrison, N. J.—Bids will be received until Oct. 1 by the Water Com. of Common Council for furnishing material and laying a water main in a portion of Franklin Ave. B. P. Walsh, Town Clk.

Belvidere, N. J.—Jos. M. Roseberry, Pres. of the Buckhorn Springs Water Co., writes that as soon as specifications are prepared bids for construction of water works will be asked. About $40,000 will be spent. S. W. Salmon, of Mount Olive, N. J., is the engineer.

Summit, N. J.—Bids will be received until Sept. 25 by the Pres. Bd. Trus., for drilling a deep well to the depth of about 1,600 ft. Jas. Johnstone, Village Clk.

**Gloucester, N. J.*—The contract to furnish a 3,000,000-gal. pump for the water works, it is reported, has been awarded to the D'Olier Eng. Co., of Philadelphia, Pa., at $3,495.

Camden, N. J.—In the report to the City Council by experts Wm. H. Boardman, J. M. Whitham and J. W. Ledoux on the increasing of the water supply, it is recommended that efficient strainers be used at the artesian wells at Delair that will increase the present output of 14,562,000 gals. to 17,000,000 daily, the metering of the entire city, and that the average daily use for each person be reduced to 125 gals. The erection of storage tanks on the hill at Bethel, near Delair, so that in the middle of the day there will be ample pressure throughout the city. These reservoirs, it is estimated, will cost $150,000. As to the future supply it is stated that the purchase of property adjoining the present plant will provide sufficient water to supply all demands of the city until 1920. This new plant, it is stated, will cost about $200,000 and will increase the output to 22,000,000 gals. daily.

A resolution has been passed by the City Council authorizing the city to borrow $3,500 to pay additional expenses of lowering the city water main in Cooper Creek at State St.

Santa Rosa, N. M.—W. S. Shields, of Chicago, Ill., is reported to have estimated the supply of water that can be taken from the canon 3 miles east of Santa Rosa at between 600,000 and 1,000,000 gals. daily. A well 600 ft. long reaching from one side of Los Tanos canon to the other is contemplated. The water is to be brought into the city gravitation. Local business men are said to be interested in the project, and it is stated that about $25,000 capital is to be subscribed.

New York, N. Y.—The following are the bids received Aug. 29 by the Park Comrs. of New York City, for furnishing, delivering and laying c. i. water pipe and appurtenances in the Harlem River Driveway between 155th and 177th Sts.: Atlanta Contr. Co., $23,810; Thos. Crimmins Contr. Co., $32,195; Wm. H. Masterson, $19,777; The Wilton Constr. Co., $23,125. The detailed bid of Wm. H. Masterson, the lowest bidder, on some of the items is as follows: 105 tons straight 6-in. c. i. pipe furnished, $38; 6½ tons 6-in. c. i. branches and special castings furnished, $100; 6,100 lin. ft. 6-in. c. i. pipe laid, $2; 750 lin. ft. 2-in. wrought iron pipe furnished and laid, $2; etc.

Albany, N. Y.—John R. Freeman, of Providence, R. I., is reported in charge of a force of engineers who are working in Sacandaga Valley to secure data concerning the State's water power resources in accordance with the Fuller Act. Mr. Freeman is to make a report to the Legislature by Feb. 1, 1908.

Niagara Falls, N. Y.—The construction of a new water system is being agitated. Three-fourths of the taxpayers are said to be in favor of Mayor A. C. Douglass' plan which involves an expenditure of about $525,000, and is to take water from the Canadian channel about half way between Navy and Buckhorn islands in the Niagara River.

**Cazenovia, N. Y.*—Geo. W. Salisbury, Pres. Water Bd., writes that no award was made Sept. 4 for furnishing and laying 5,433 ft. 4-in. c. i. pipe. The city will probably buy the material and let contract for labor.

Brooklyn, N. Y.—Bids were opened on Aug. 28 at the office of the Comr. of Water Supply, Gas and Electricity, N. Y. City, for furnishing, delivering and laying water mains and removing existing water mains in Bedford, Clinton, Greenpoint, Harrison, Johnson, Manhattan, Meserole and Nassau Aves.; in Humboldt, Keap, Lorimer, Meserole, Oakland, Provost, Scholes, Waterbury and White Sts., and in Delmonico Pl., Boro. of Brooklyn, and the lowest bid received was submitted by J. H. Holmes, 87 Nassau St., N. Y. City, at a total of $317,817. The following is his detail bid of some of the principal items required: 3,560 tons straight pipe, $37.50; 360 tons specials, $75; 350 tons gate valve boxes, $54; 75 lin. ft. 30-in. pipe to lay, including excav., $3; 25 lin. ft. 24-in. pipe to lay, including excav., $2.50; 6,700 lin. ft. 20-in., $1; 40,200 lin. ft. 16-in., 90 cts.; 7,400 lin. ft. 12-in., 73 cts.; 5,600 lin. ft. 8-in., 72 cts.; 2,800 lin. ft. 6-in., 35 cts.; 350 sq. yds. Belgian block pavt., 30 cts.; 6,200 sq. yds. granite block pavt., 30 cts.; 6,500 sq. yds. granite block, concrete found., $1.60; 1,000 sq. yds. cobble pavt., 20 cts.; 7,500 sq. yds. asphalt, $1.90; 300 sq. yds. asphalt block, $1.90; 450 sq. yds. brick pavt., $1.60; 150 sq. yds. Medina sand stone, $1.20; 1,500 sq. ft. flag, 10 cts.; 500 sq. ft. cement sidewalk, 20 cts.; 50 cu. yds. brick masry., $15; 50 cu. yds. concrete, $10; 10 M ft. lumber, 1 ct.; 5,000 lbs. steel I-beams, 3 cts.; 1,000 cu. yd. extra excav., $1.50; 100 cu. yds. rock excav., $2.50; 2 16-in. connections 30-in. pipe, $450; 1 12-in. connection 30-in. pipe, $300; 1,000 ⅜-in. house connections, $1.50; 100 ½-in. house connections, $1.75; 100 ⅝-in. house connections, $2; 50 1-in. house connections, $3; 25 2-in. house connections, $7; 100 hydrants removed, $10; 50,000 lin. ft. 6-in. pipe removed, 1 ct. Totals of other bids: Shawmut Constr. Co., 301 S. 3d St., Brooklyn, $322,567, and Hanover Constr. Co., 21 Park Row, $336,365.

The Kings Dept. of Parks is reported to have awarded to Barton & McHarg, of New York City, N. Y., the contract to construct a water system to supply the club house and nursery for Forest Park. Probable cost, $15,000.

Ft. Caswell, N. C.—Bids will be received until Oct. 9 by L. Cravens, Quarter Master, Ft. Caswell, for building pump house, ice plant and cold storage here, as advertised in The Engineering Record.

Kings Mountain, N. C.—See "Power Plants, Gas and Electricity.

Charlotte, N. C.—Bids will be received until Sept. 19 by the Bd. of Water Comrs. (Patk. H. Williams, Supt.), for furnishing approximately 440 tons c. i. pipe and specials, 37 Matthews pattern fire hydrants, anad valves of 6-in., 8-in., 12, 16 and 20-in. sizes; also same date and place separate bids for laying approximately 1,800 ft. of 20-in., 4,150 ft. 12-in. and 250 ft. 6-in. water mains together with necessary valves, hydrants and specials.

**Cincinnati, O.*—Frank Burns is stated to have secured the contract for laying 12-in. pipe in Grand, Warsaw and Price Aves., at $2,532, and for laying 8-in. filtered water pipe at California, at $1,983. The American Steel & Wire Co. is reported to have secured the contract to furnish 1,100 tons of sulphate of iron at $13,200.

The Selvage Constr. Co. is reported to have submitted the lowest bid for furnishing 28 fire hydrants.

**Sandusky, O.*—The contract to construct a mechanical filter plant (bids received June 29) was awarded recently to Thos. Sightbody, of Youngstown, at $75,000 complete, 6,000,000 gal. capacity. It is to be of concrete construction.

Mosquite, Ore.—Bids will be received until Oct. 26 by Saml. Hill, Chmn. Snake River Irrigation Dist., Mosquite, for $325,000 irrigation bonds.

**Halbur, Ia.*—Fred Franzwa, of Carroll, is stated to have secured the contract to construct water works at $3,865.

Seneca, S. C.—It is reported that bonds have been voted to establish a water plant.

Dickson, Tenn.—We are informed that the citizens have voted in favor of issuing $25,000 bonds for water works. Bids for construction not yet advertised.

Victoria, Tex.—The City Council has instructed the Com. to advertise for artesian water, the quantity to be not less than 700 gals. per minute, or 1,008,000 gals. per day.

Bronte, Tex.—The question of installing a water works system is reported contemplated. The forming of a company by local capitalists to bring water from Colorado River, a distance of 3 miles, is being considered.

Beaumont, Tex.—The Beaumont Water Wks. Co. is stated to have authorized an issue of $250,000 in bonds for improving the plant.

Fair Haven, Vt.—It is proposed to extend the water system by constructing 2 additional reservoirs and laying pipe, at a total cost of $15,000. Bids will be opened within a month. Washburn Fancher, of Fair Haven, is the Engr. in charge.; D. J. Durick, Village Pres.

Lind, Wash.—R. S. Hamilton, Town Clk., writes that no improvements are contemplated at the present time by the city to the water works recently purchased.

Tacoma, Wash.—An ordinance has been approved by the Mayor to lay 6-in. c. i. water pipe and 6-in. wooden water pipe in Local Improv. Dist. No. 517, including hydrants, gates, tees, etc.

*The report of the Special Water Com. recommending to the Council that the bid of the Los Angeles Well Drilling Co. for sinking an experimental well at South Tacoma at $7,500 be accepted, was adopted by Council.

**Seattle, Wash.*—The contract to lay water mains in 3d Ave. W., is stated to have been awarded to H. F. Johns at $11,875.

Union, W. Va.—Bids will be received until Oct. 5 by A. S. Johnston, Mayor, for $5,500 bonds, to be issued for the purpose of constructing a system of water works.

Kingwood, W. Va.—A local water company has been formed and, it is stated, has applied to the City Council for a franchise to establish a water works system.

Elkins, W. Va.—Water works bonds have been sold and bids for the construction will be received Sept. 20. Geo. Henry, City Clk.; Penniman & Fairley, Engrs., Baltimore, Md.

Parkersburg, W. Va.—G. L. McGibbons is reported to have been engaged by the Bd. of City Affairs to prepare plans for the construction of a water works system. J. V. Dunbar, City Engr.

Madison, Wis.—Bids will be received until Sept. 27 by the Bd. of Water Comrs. (John B. Heim, Supt.) for constructing a 1,000,000-gal concrete storage basin; also, same date and place, separate bids for drilling 1 and possibly 2 artesian wells, both proposals advertised in The Engineering Record.

**Fond du Lac, Wis.*—The City Council Aug. 26, it is stated, accepted the bid of S. H. Cole for laying a gravity intake water system in the northern extremity of

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**Items marked thus give the names of parties awarded contracts.*